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# THE
# CONSTRUCTION
# OF
# PUMP DETAILS.

# THE
# CONSTRUCTION
# OF
# PUMP DETAILS.

BY

**PHILIP R. BJÖRLING,**

AUTHOR OF "PRACTICAL HANDBOOK OF PUMP CONSTRUCTION," &c.

WITH 278 ILLUSTRATIONS.

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# PREFACE.

Attention was called by reviewers of the Author's 'Practical Handbook on Pump Construction' to the lack of details therein, and numerous requests for such information have shown how great is the need for particulars of this kind.

It is with pleasure, therefore, that the Author submits this book, trusting that the information given will supply the requirement, at least to some extent.

Most of the illustrations are from actual practice, and are drawn to scale. Dimensions are given where possible.

Valves are but briefly dealt with, being fairly explained in the 'Practical Handbook on Pump Construction.'

The Author wishes it to be clearly understood that here a "*pump*" implies the *hydraulic apparatus* used in raising or forcing liquids, and not the *steam part*, hence the details in this book are strictly confined to the water or hydraulic part of the apparatus.

P. R. B.

Hitchin, 1892.

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# THE CONSTRUCTION

# OF

# PUMP DETAILS.

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## WINDBORES.

THESE are divided broadly into two classes, namely:—

### FIXED AND SLIDING WINDBORES.

Windbore is the usual term for the suction-pipe of large pumps. It is secured to the bottom pump or clack-piece by its top flange, and should be made as short as possible. In no instance should the distance from the bottom of the snore-piece to the top of the bucket in its highest position be more than 25 feet; the object of the snore-piece or strainer being to prevent chips and other foreign matter from entering the pump and choking the valves.

### FIXED WINDBORES.

Three different shapes of fixed windbores are illustrated in Figs. 1, 2, and 3.

Fig. 1 consists of an ordinary pipe, A, with a flange, B, at its upper end, which latter is bolted up to the bottom of the pump or clack-piece. The bottom part, D, of the windbore, generally called the *snore-piece* or *strainer*, is enlarged and perforated with holes. These windbores are called ***Flat-bottomed windbores***, and mostly used when the water in the well or sump is shallow, or when the pump is drawing the water or other liquid from a tank in the pit or mine shaft.

*Conical-ended windbores* are usually employed when sinking shaft or wells, and are frequently used in Cornwall. This example is taken from a 22-inch bucket-lift, and illustrated by Fig. 2. It will be seen that the "snore-piece," D, in this case is a plain pipe rounded at the end, instead of it being enlarged, as in Fig. 1. The pipe A is 21 inches diameter; the "snore-piece" has 198 holes, 1¾ inch diameter, placed in 11 rows, 18 holes in each row.

FIG. 1.

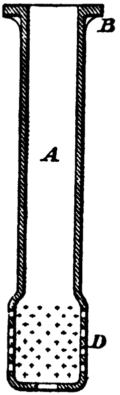
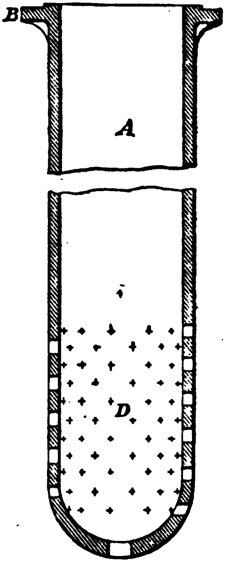


FIG. 2.



The third fixed windbore, illustrated in Fig. 3, is termed an *egg-ended* or *heart-shaped windbore.* The "snore-piece," D, in this type is swelled out, but instead of having a flat bottom it is rounded, being really a combination of Figs. 1 and 2.

FIG. 3.

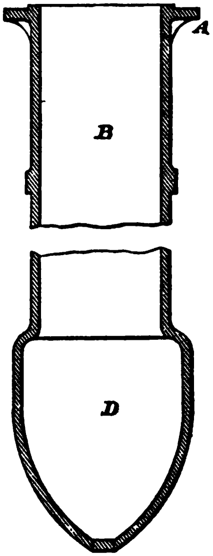
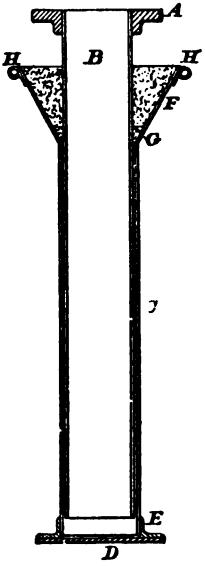


FIG. 4.



## SLIDING WINDBORES.

Sliding or Telescope windbores derive their name from the external pipe being free to slide up and down on the internal or fixed pipe in a telescope fashion. The advantage of this arrangement is that when the pump is used for working under the "sinkers," the men can work under the windbore until it has come down the length allowed in the slide, usually 9 feet to 10 feet, which is as far as the pipe can slide, being the length of pipe generally used in all classes of pump and pit work; then the joint between the top flange on the fixed pipe and the bottom flange of the clack-door-piece is broken, and another

FIG. 5.

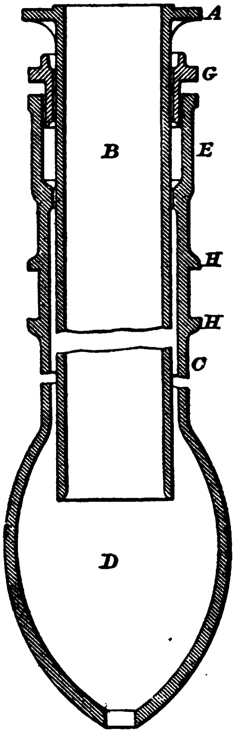
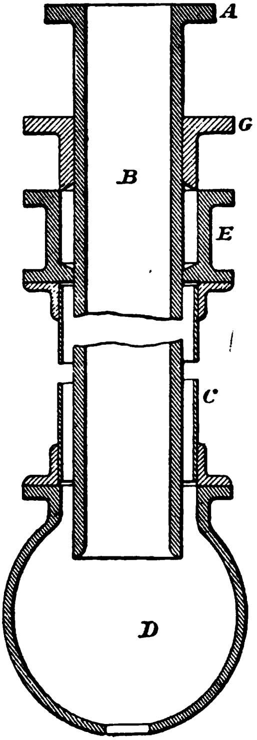


FIG. 6.



length of pipe put in between the two flanges. When the suction-pipe gets too long for the pump to draw water, the additional pipes are removed, the pump lowered down to its proper level from the surface of the water, the spears or pump-rods lengthened, and the additional pipes are added to the rising main or pump "trees," until the shaft or well has attained its desired depth.

*Sliding Windbores* are shown in Figs. 4, 5, 6, 7 and 8.

Fig. 7.

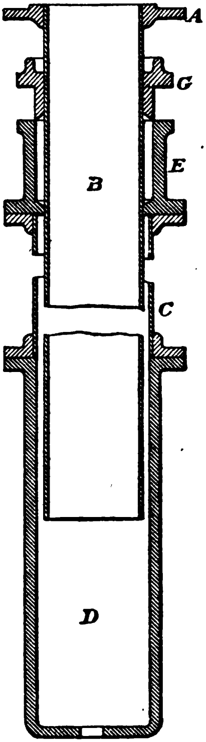
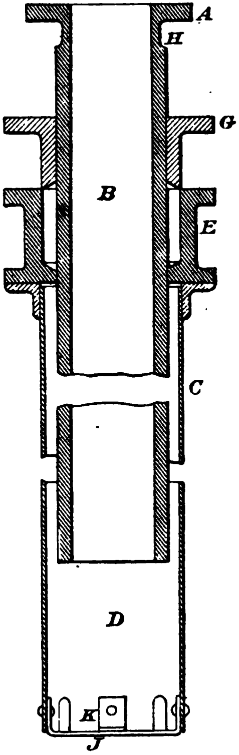


Fig. 8.



A cheap sliding windbore is illustrated in Fig. 4, which is used for ordinary well-sinking and temporary work. It consists of the fixed pipe, B, preferably made of wrought-iron on account of its lightness, secured to the bottom of the suction-clack-piece, by means of the flange A; C is the outer or sliding-pipe, closed at the bottom by a plate, D, secured to the angle-iron ring E; the bottom part of the sliding-pipe is perforated in the usual manner, and the top part is furnished with a funnel; at the bottom of this funnel is placed a ring of plated hemp, the remaining part being filled with well-worked clay, to prevent the admission of air. The clay must be replaced every time the sliding-pipe has been lowered. Some well-sinkers use clay only, but it is better to use hemp also, as it prevents clay from getting into the sliding-pipe. H H are two eyes, by means of which the sliding-pipe C is raised and lowered.

Fig. 5 is a cast-iron sliding windbore with a heart-shaped snore-piece, D, made for a 12-inch diameter suction-pipe. A is the flange, by means of which the fixed pipe B is secured to the pump or clack-piece; B is the fixed pipe; C the sliding-pipe; D the snore-piece; E the stuffing-box, cast in one piece with the sliding-pipe C; sometimes it is made separate and secured to the sliding-pipe by means of bolts and nuts, as in Fig. 6; G is the gland. There are two belts, HH, provided on the sliding-pipe, C, for raising and lowering the pipe. Instead of these belts, a lug is cast on each side for attaching the chains or ropes, whichever may be used, as shown at HH, Fig. 4. This arrangement is also used for the fixed windbore, for raising and lowering the whole bucket-lift; at other times a pair of trunnions are furnished on the windbore for lowering the whole lift, as is illustrated in Fig. 274, and will be described further on. These letters refer also to the corresponding parts in Figs. 6, 7 and 8. Some engineers prefer the fixed pipe turned, and the glands and stuffing-boxes bored, but the usual manner is to cast the gland and stuffing box $\frac{1}{4}$ to $\frac{3}{8}$ inch larger in diameter to allow the pipe sliding easily without being turned.

Many colliery engineers and shaft-sinkers prefer to have the fixed pipe of cast iron and the sliding-pipe of wrought iron, it being lighter and consequently easier to handle. This kind of sliding windbore is illustrated in Fig. 6. The snore-piece, D, was made of cast iron and globe-shaped. The fixed pipe was 8 inches in diameter.

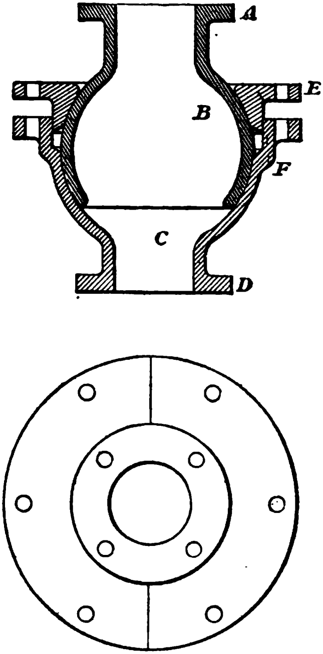
Another style of sliding windbore is illustrated in Fig. 7, in which both the fixed pipe, B, and the sliding-pipe, C, are of wrought iron; the snore-piece, D, stuffing-box, E, and gland, G, are made of cast iron. In this instance the snore-piece, D, is made straight of the same internal diameter as the sliding-pipe, which in the case before us is 14 inches in diameter, and flat bottom, and perforated with 210 holes, 1¼ inch diameter, in 21 rows of 10 holes in each row, the internal diameter of the fixed pipe being 12 inches, both pipes being ¼ inch thick.

The last sliding windbore the author will refer to is illustrated in Fig. 8. The fixed pipe, B, is of cast iron, the sliding-pipe, C, and snore-piece, D, are of wrought iron, the stuffing-box, E, and gland, G, of cast iron. In cases where the fixed pipe, B, is made of cast iron and turned, the outside diameter of the pipe should be made slightly less in diameter for a length of about 6 inches, under the flange, A, at H, to prevent a ridge where the turned part finishes. This windbore was made for an 8-inch suction, the fixed pipe being 8 inches internal diameter, and the sliding pipe 12½ inches diameter by ⅜ inch in thickness. Instead of the holes in the snore-piece being round, as they usually are for mine pumps, slots 3 inches deep by 1 inch wide are substituted. The bottom end, J, is quite open, and strengthened by two cross-stays, K.

## SWIVELLING OR SWINGING WINDBORE.

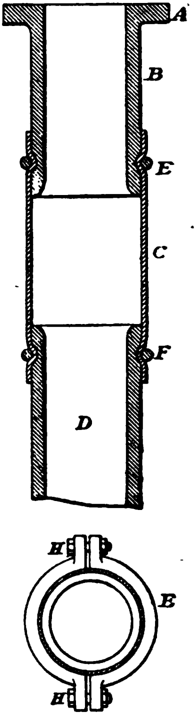
Sometimes it is useful, whilst sinking, to have the windbore arranged so that it can be swung out of the way when sinking under the centre line of the pump. In such cases, either a ball-and-socket joint, a short piece of flexible pipe, or a long flexible suction-pipe, without windbore, is employed.

FIGS. 9, 10.



The *ball-and-socket joint* is illustrated in Figs. 9 and 10. It consists of a ball, B, turned true, the flange, A, being bolted to the bottom of the clack-piece; C is the socket, which is bolted, by the flange D, to the windbore, fixed or sliding, as the case may be. This socket is turned on the inside to ensure the ball being perfectly air and water tight; E is a gland, fitted to the socket-pipe, C, which latter is formed into a stuffing-box at F. The gland, E, is also turned on the inside to fit the ball, B, and is made in two halves to allow it to be fitted. Fig. 10 is a plan showing the six bolts, by means of which the packing in the stuffing-box is tightened. This ball-and-socket joint was made for a 5-inch diameter windbore.

FIGS. 11, 12.



The *flexible joint* consists simply of a short length of india-rubber, leather or canvas tubing secured to a short piece of pipe, B, by wrought-iron clips, bolted to the bottom flange of the clack-piece by means of the flange A, as shown in Figs. 11 and 12, in which A is the flange, B the short cast-iron pipe, C the flexible pipe of india-rubber, leather, or canvas, or other flexible material; D is the top of the windbore, fixed or sliding, and E and F are the two wrought-iron clips by means of which the flexible pipe is secured to the cast-iron pipes. The clips are tightened up by means of the bolts H, shown in plan (Fig. 12).

In many cases, especially in Mexico, a flexible suction-pipe, with a galvanised iron strainer, is substituted for the windbore, the flexible pipe being made of india-rubber, leather, or canvas.

### REMARKS ON DESIGNING WINDBORES.

The *holes* in snore-pieces are usually 1¼ inch to 1¾ inch in diameter, the collective area of which should be at least 1½ times the area of the windbore, and for sewage purposes they ought not to be less than twice the area of the pipe.

In many instances for sewage pumps the holes are *slots*, generally 1 inch wide by 3 inches deep.

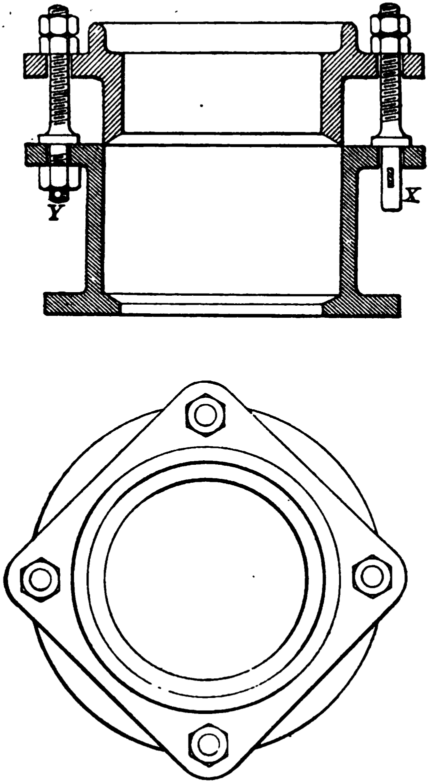
Snore-pieces or strainers are not always used for sewage pumping; in many instance the holes in the snore-pieces cannot be kept clean, therefore the valves are made of the clack type, and all rubbish which passes the sewage screens or gratings is allowed to pass into the pump.

The glands are mostly made with square flanges, as shown in Figs. 13 and 14, and the studs for tightening the gland are either cottered fast, as shown at X, or secured by means of nut and split-pin behind it, as at Y. Sometimes, but seldom, the flange of the gland is made circular, but that only in case of very large pipes.

The length allowed for the sliding windbore varies with the engineer's fancy, the usual plan being to make the fixed pipe of such a length as to allow the sliding pipe a range of 10 feet to give room enough for an ordinary 9-foot length of pipe to be put in. Some engineers are satisfied with admitting only a 6-foot matching-piece at a time.

There is no fixed rule for the thickness of metal in the windbore; it is usually settled by the engineer's experience. To make it of the strength required for the actual work it has to do would not be practicable; it must be made very strong on account of the ill-usage it has to bear, and is mostly made of the same thickness as the clack-piece and **H**-piece, but for ordinary pump work, as water-works wells, the pipes will do of the same thickness as ordinary steam pipes of the same diameter.

Figs. 13, 14.



## FOOT-VALVES AND STRAINERS.

When the suction-pipe is long and the lift high, a foot-valve should always be provided, to retain the water in the suction-pipe, or it will be necessary to charge the pump every time it has to be used.

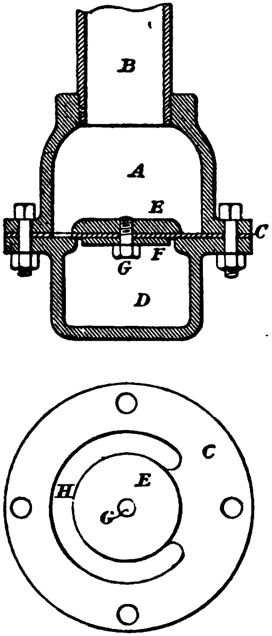
The strainer, the name given to the snore-piece when of a small size, should be provided to prevent chips, pebbles, and other foreign matter entering the pump and choking the valves.

The most simple and common foot-valve is illustrated in Figs. 15 and 16. Fig. 15 is a sectional elevation, and Fig. 16 a plan of the valve. A is the valve-box body; B the suction-pipe, in this case 2½ inches diameter, and screwed into the top of the valve-box body A; C is the leather, forming both the clack-valve and the joint between the body, A, and the strainer or snore-piece, D; E is the top clack-plate, F the bottom clack-plate, both being secured to the leather, C, by means of the screw G. The strainer has 168 holes, ¼ inch diameter, 24 holes in each row. The leather, C, is cut to the size of the outside diameter of the flange, and a piece, to the shape shown in plan, Fig. 16, at H, cut out; this slit must be cut so that a lap of $\frac{1}{10}$ inch, for every 1 inch of the diameter of the waterway, is allowed all round.

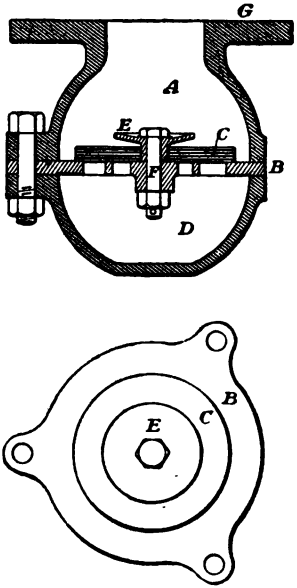
A 3-inch foot-valve and strainer, fitted with india-rubber disc-valve, is shown in sectional elevation by Fig. 17, and plan, Fig. 18. It consists of a valve-box body, A; valve grid, B; india-rubber disc, C; valve guard, E;

and centre spindle or centre bolt, F. In this case it is secured to the suction-pipe by a flange, G, instead of being screwed, as in the previous example. The strainer, D, was perforated by 54 holes, $\frac{7}{16}$ inch diameter. The valve-box body, A, grid, B, and the strainer, D, are held securely together by three bolts, as shown in Fig. 18, which is a plan with the valve-box body, A, removed.

Figs. 15, 16.



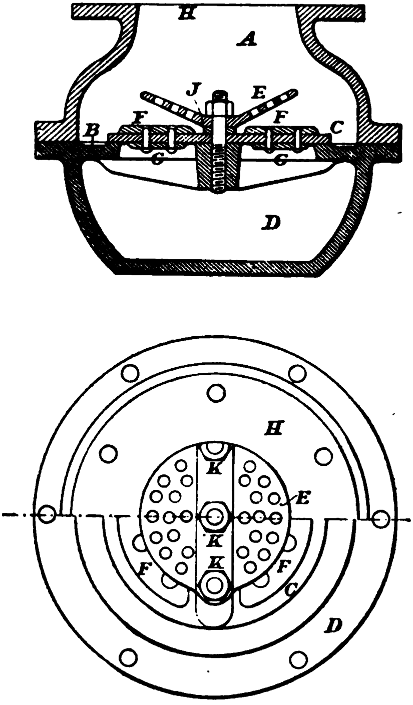
Figs. 17, 18.



We now come to a foot-valve fitted with leather butterfly valve. This is illustrated in a sectional elevation (Fig. 19) and a half-sectional and half-elevational plan (Fig. 20). A is the valve-box body; B, valve seat;

C, butterfly valve, so named by reason of its supposed resemblance to the wings of a butterfly; E, the valve-guard, which determines the lift of the two clack or wings; F F are the two top valve plates; G G, the

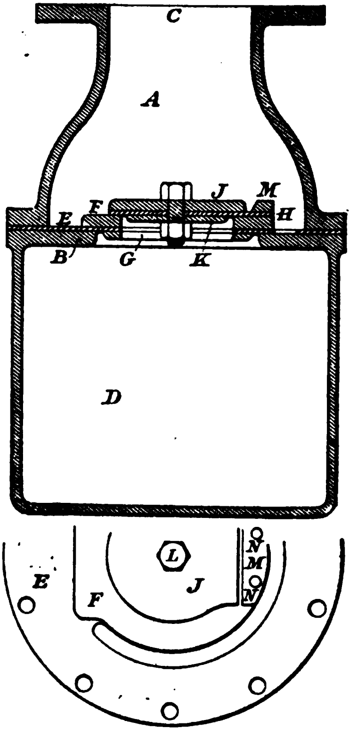
Figs. 19, 20.



under or bottom valve plates, which are in this case riveted to the leather clacks, although it is far better and more convenient, when the leathers want renewing, to have them bolted together; D is the strainer, and, as in the previous examples, is furnished with circular holes;

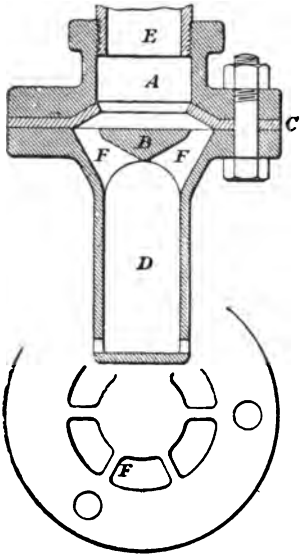
H is the suction-pipe, 9 inches in diameter; J is a wrought-iron cross-plate inserted between the clack-leather and the guard; the whole is secured to the grid by means of the three screws K, K, K.

Figs. 21, 22.



A very useful and quiet working foot-valve, for large sizes, is shown in Figs. 21 and 22, of which Fig. 21 is a sectional elevation, and Fig. 22 a half-plan with the valve-box body removed. A is the valve-box body; B the valve seat; C the suction branch, of 9 inches diameter in the one illustrated; D is a flat-bottomed strainer, but can of course be made of any desired shape; E is the main valve, forming the joint between the valve-box body A and the strainer D; F is the top, and G the bottom valve-plate. These two plates and the leather are riveted together and furnished with a circular hole through the centre, which is usually from one-half to one-third of the area of the main valve opening. On the top of this main valve is secured another leather clack, H, fitted with a top plate, J, and a bottom plate, K, held together by the centre bolt, L, and secured to the main or bottom valve by means of the plate, M, and the two screws N, N. It will be seen that the two valves open in opposite directions, reducing the shock so common and injurious in large clack-valves.

Figs. 23, 24.



A very simple foot-valve and strainer is illustrated in Figs. 23 and 24. It consists of a valve-box body, A, secured to the valve seat, B, cast in one with the strainer D; between these two is fastened an india-rubber disc, C, which has a hole through its centre equal to the area of the suction branch, E, in this case 3 inches in diameter, the water passing through the hole in the india-rubber disc and up the suction-pipe, which latter is screwed into the suction branch. The centre of the seat, B, is joined to the casting, D, by means of six ribs, F. The india-rubber disc-valve is shown open in Fig. 23 to show that the body casting, A, forms a stop to prevent the rubber from bending too far.

All the foot-valves described so far have one objection, viz., that the strainer must be removed before the valve can be got at. The one illustrated in Figs. 25, 26, and 27 is provided with a door for access to the valve. It consists of the valve-box body A, inlet, B, outlet, C, valve-box door, D, cast-iron clack-valve, E, faced with leather, and having a plate underneath, all the three being held together by a rivet or bolt. The valve, E, is hinged to a lug on the door, D, by means of the pin, F,

Fig. 25.

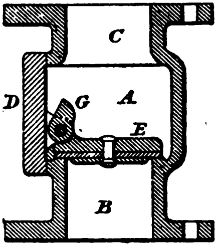


Fig. 26.

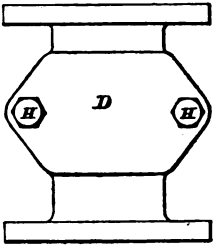


Fig. 27.

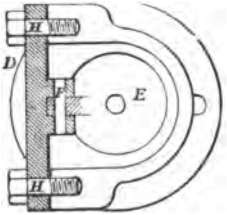
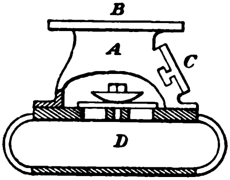


Fig. 28.



so that when the two screws, H, H, which secure the cover, are removed, both the cover and valve can be removed together. G is a horn provided on the valve E, to prevent it rising too high. The suction-pipe on the valve illustrated is 2½ inches diameter.

A very good foot-valve and strainer, especially suitable for shallow water, is illustrated, partly in elevation and partly in section, by Fig. 28. It has the advantage of being fitted with a door for easy access to the valve, through the cover, C, and is furnished with an india-rubber disc-valve. The strainer, in this case, is very shallow, and furnished with long and narrow slots, instead of round holes, which slots are only about $\frac{1}{16}$ inch wide on the inside, but about ½ inch wide at the outside circumference of the strainer.

## REMARKS ON DESIGNING FOOT VALVES AND STRAINERS.

Arrangement should be made for easy access to the valves by means of *doors*. This rule is very often neglected. When the valves and pipes are small, and valves under water, then, of course, it is not of much moment; but for large valves it should be enforced.

The strainer should be made of the most *suitable shape* for the purpose for which it is intended. For instance, if the water in the well, sump, or tank is not very deep, a shallow strainer is the most suitable.

The *holes* in the strainer should be made much smaller than in the snore-piece at the bottom of a windbore, ranging, as they do, from ¼ inch to 1 inch in diameter.

The *aggregate area of the holes* in the strainer, when the holes are very small, should be two to three times the area of the suction-pipe. An American author says five times the area of the suction-pipe.

In small sizes—say up to 3 inches in diameter—the *pipe* is usually *screwed* into the top of the valve-box, A, as in Figs. 15 and 23; but when the pipe is 3 inches in diameter, or above, they are generally secured to the valve-box body by flanges and bolts or studs, the former in preference. It is by far the best plan to have the flanges and nuts made of brass; they are then easier to unfasten from the suction-pipe.

The water-way through the valve ought to be at least of the same area as the suction-pipe, or, by preference, a larger area than the internal diameter of the pipe, because the water enters only by the pressure of the atmosphere; therefore, the less friction through the valve and pipe, the more likely it is that the pump will be completely filled with water at each stroke.

# CLACK-PIECES, BUCKET-DOOR-PIECES AND H-PIECES.

## Clack-pieces or Clack-door-pieces.

Clack-pieces or valve boxes, as they are sometimes called, are of two classes, quite identical in every way; one is the suction clack-piece, secured between the windbore and working barrel in a bucket-lift; the other is fixed on the top of the **H**-piece, between that and the rising main or pump trees, or air-vessel, if one is used, in plunger-sets.

Fig. 29.

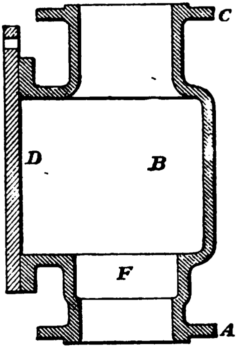
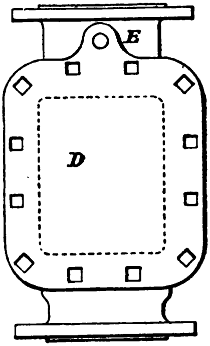


Fig. 30.



The ordinary clack-piece used in pit work for light pressures is illustrated in Figs. 29, 30 and 31. Fig. 29 is a sectional elevation, Fig. 30 front view showing the door, and Fig. 31 a sectional plan of a clack-piece for a 12-inch diameter plunger-set working against a head of 35 fathoms.

A is a flange by which the clack-piece is secured to the top of the H-piece; B is the valve-box or chamber; C the flange to which the rising main or pump trees are bolted; D is the valve-door, provided with a lug E, to which a shackle is secured when the door is removed. Sometimes the lug is cast on the face of the door, D, as shown on the H-piece (Fig. 41). The flanges, A and C, are sometimes faced right across, but mostly only a narrow facing ring is formed on the flange. The valve-seat is shown at F; this is generally bored out to receive the clack-body or shell, and the door and the face of the clack-piece are planed, sometimes straight across, at other times only a narrow facing, as on the flanges A and C.

FIG. 31.

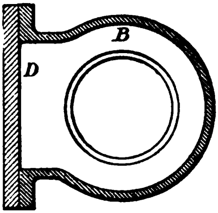


FIG. 32.

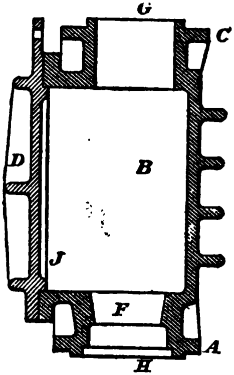
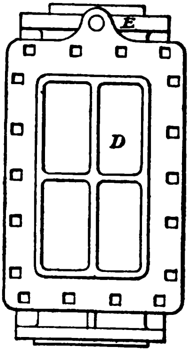


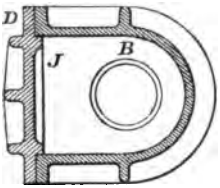
FIG. 33.



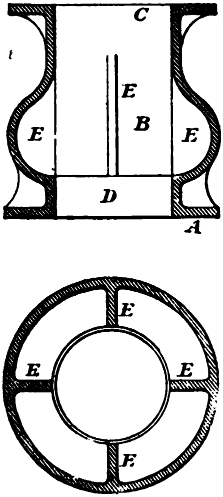
A clack-piece for heavy pressure, used for a 9-inch diameter bucket-lift, is shown in sectional elevation Fig. 32, front elevation Fig. 33, and sectional plan

Fig. 34. In this example the valve is made to drop through the working barrel, in case the clack-piece should be covered with water. The clack can be drawn up by rods furnished at the end with a fish or hook, to be illustrated and described later on. The clack-piece for bucket-lifts is secured between the windbore and the working barrel. It will be seen that the top part, C, is furnished with a spigot, and the bottom, H, is recessed to form a socket, to receive a spigot formed on the top of the windbore. It will also be seen from Figs. 32 and 34 that the cover is furnished with a projection, J; this projection serves the two-fold purpose of holding the jointing material in its proper place and keeping the door central, making it easier to remove the bolts, the weight not resting on them.

FIG. 34.



FIGS. 35, 36.



DROP CLACK-PIECE.

The drop clack-piece is similar to the ordinary clack-piece, but it is made shallow, and it is not provided with a door, as will be seen from Fig. 35, which is a sectional elevation, and Fig. 36, a sectional plan, showing the guide ribs.

The object of the drop clack-piece is, that when the pumps are situated in places likely to be flooded, then if the water has risen above the ordinary clack-piece door, and the bottom- or suction-clack is out of order, the drop-clack can be lowered down through the pump trees, and the pump can go on working till access can be had to the clack-piece door and the valve repaired.

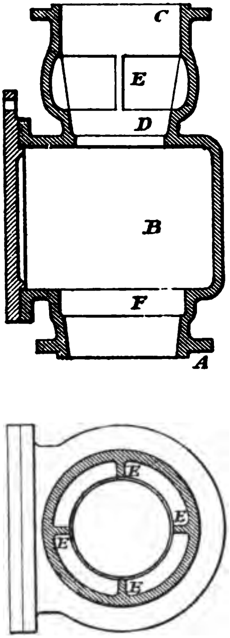
In the interior of the drop clack-piece are formed three or more ribs or webs, according to the size of the valve, for guiding the drop-clack into its place, at the bottom, marked D. A is the flange which is bolted on to the top of the ordinary clack-piece; B is the drop clack-box or chamber; C the flange which is bolted to the working barrel; D is the seat formed in the clack-piece, which is bored out to receive the clack-shell. The top and bottom flanges are usually faced. E, E, E, E, are the guide ribs, for guiding the clack into its place. The diameter of the top part, C, is generally made a little less than the working barrel to prevent the bucket from getting down on the valve in case any breakage should occur. This drop clack-piece was designed and used for a 21-inch diameter bucket-lift.

### CLACK-PIECE AND DROP CLACK PIECE COMBINED.

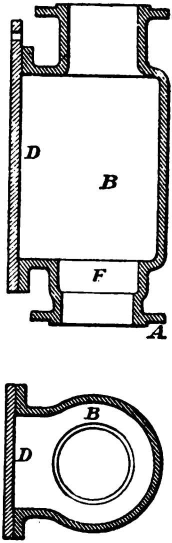
Sometimes the drop clack-piece is cast in one with the ordinary clack-piece, as shown in Figs. 37 and 38. Fig. 37 is a sectional elevation, and Fig. 38 a sectional plan showing the guide ribs. This arrangement is objectionable, because if one or the other part should burst or in any way become disabled, both will have to be thrown away. Another reason is that it will be necessary to keep an additional special clack-piece in stock at the mine or colliery. This clack-piece was made for a 20½-inch bucket-lift.

Some engineers prefer to have two clack-pieces and two clacks for bucket-lifts, one above the other; also two delivery clack-pieces and clacks for plunger-sets, in case one should fail, rather than having the trouble with the drop-clack and piece; because the drop-clack must be less than the bucket, or else it could not be passed down, consequently the drop clack-piece must be less than the bucket, which reduces the water-way, and increases the friction of the water through the contracted passages.

Figs. 37, 38.



Figs. 39, 40.



## Bucket Door-piece.

The bucket door-piece is secured between the top of the working barrel and the bottom of the pump-trees, or "pumps," as they are termed in Cornwall. The object of this door-piece is to give access to the bucket without drawing it all the way up the pump-trees to the top of them. To secure this object the doorway is made of such a depth that the bucket and bucket-sword or bucket-prong, as the case may be, can be removed through it easily, by simply knocking it off at the knock-off joint, which is always provided.

One type of bucket door-piece is illustrated in sectional elevation Fig. 39, and sectional plan Fig. 40. This piece was made for a 12-inch bucket-lift, and the door-way was 2 feet 7 inches deep, and the clack-piece was made of the same pattern, requiring only one to be kept in reserve, hence the part F being shown with a seat for the clack.

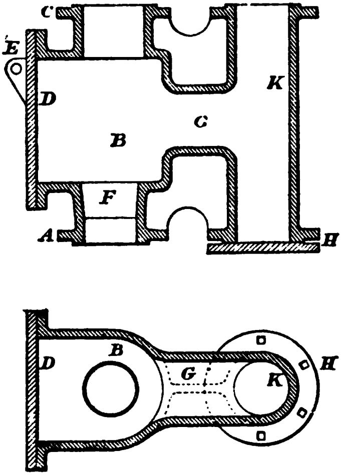
Generally the part F and C are made parallel, of the same diameter as the pump-trees—that is, from ½ inch to 1 inch larger in diameter than the bucket.

In some cases a spigot is formed on the top of the working barrel, which reaches level with the bottom of the chamber B. The latter is a very good plan, it being more easy to see when the bucket is in the right position for being lowered down into the working barrel.

## H-PIECES.

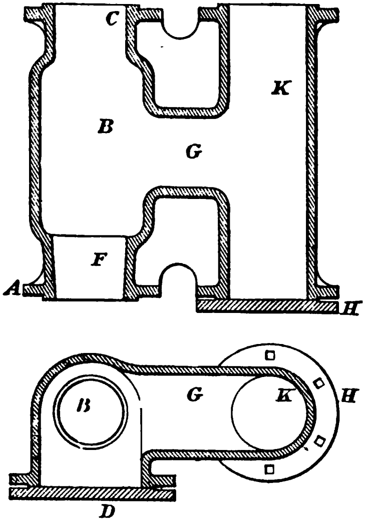
There are two varieties of H-pieces. The first is shown in sectional elevation Fig. 41, and sectional plan Fig. 42, made for a 7-inch plunger set working against a head of 300 feet. A is the flange to which the windbore is bolted; B the valve-chamber; C the flange to which the plunger-case is secured by means of bolts; D is the door for access to the clack or valve. It is always best to have this door opposite the water-way G, because the hinge of the clack is always facing the door, and the clack opens towards the water-way, hence the water is guided into the proper direction. K is a pipe, to the top of which the delivery clack-piece is bolted, the bottom of this pipe being closed by a blank flange, which in some cases rests on a piece of timber, which again rests on the bottom of the tank or cistern in the shaft; in other cases a beam of timber is carried above the tank; and again, sometimes a pipe, called a "stand-pipe," of cast-iron, is used instead of the upright timber or horizontal beam.

Figs. 41, 42.



The second variety of H-piece is for a 9-inch plunger set, and illustrated in Figs. 43 and 44, Fig. 43 being a sectional elevation and Fig. 44 a sectional plan. In this case the flange, A, is, as before, bolted to the wind-bore, but the plunger case is bolted to the top of the pipe, K, and the delivery clack-piece is bolted on the top of the flange, C, so that the windbore, suction-clack, delivery-clack, and rising main are all in a straight line. It will also be seen, from the plan, Fig. 44, that the door is placed at right angles to, instead of in a line with, the water-way, G. In this instance there was no objection to this arrangement, as the valves were of the perpendicular lift type.

Figs. 43, 44.

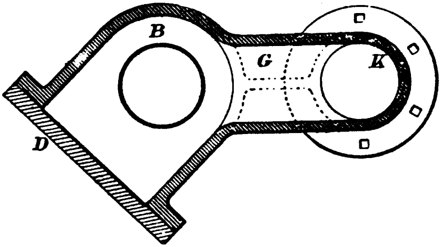


There are many modifications in the arrangement of the relative positions of the clack-chamber, B, upright pipe, K, and water-way, G, to suit different circumstances, such as to give more room in the shaft, easier access to the clack-door and clacks, etc. One arrangement is shown in sectional plan, Fig. 45, in which the door, D, is placed at an angle of 45 degrees to the water-way, G. As regards the flow of water, when clacks are used this angle is better than 90 degrees.

In very large pumps the clack-chamber, B, and pipe, K, are cast in two pieces and bolted together at the waterway, G. In very small sets the H-piece and delivery clack-piece are sometimes cast together.

Sometimes the bottom part of the plunger case and the delivery-clack door-piece, in plunger-sets, are cast together, the remainder of the case being bolted to the top of it, similar to the ordinary H-piece without the waterway between the two parts.

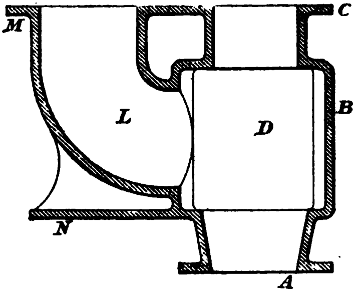
Fig. 45.



## Knee-Pieces.

In many instances a knee-piece, as illustrated in Fig. 46, is adopted instead of the H-piece. It will be seen that there is very little difference between the two. A is the flange to which the windbore is secured; B is the valve chamber; D is the valve door-way; C the flange to which the clack-piece is bolted; but instead of the water-way, G, and pipe, K, a bend, L, is cast on the side of the valve chamber, having a flange, M, on to which the plunger-case rests, and a foot, N, is provided underneath the bend, L, on which the whole of the plunger-set rests. This arrangement is without a doubt better than the **H**-piece, as it gives an easier flow for the water through the curve.

FIG. 46.



Frequently the pumps are secured to beams in the shaft instead of in a tank or cistern, and the water supplied from a lodgment in the shaft. In such cases a bend is secured underneath the **H**-piece to the flange, A.

FIG. 47.

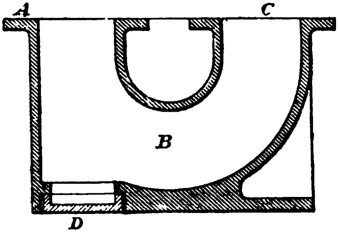
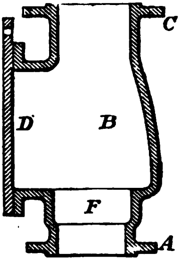


FIG. 48.



This is illustrated in Fig. 47, which is a sectional elevation; B is the water-way, and C the flange bolted up to the underside of the tank or sump; or it receives its water direct from the next lift below by a pipe leading from the top of the pump-trees. D is a plug secured by soft wood wedges or rust cement.

## REMARKS ON DESIGNING CLACK-PIECES, BUCKET-DOOR-PIECES, H-PIECES, AND KNEE-PIECES.

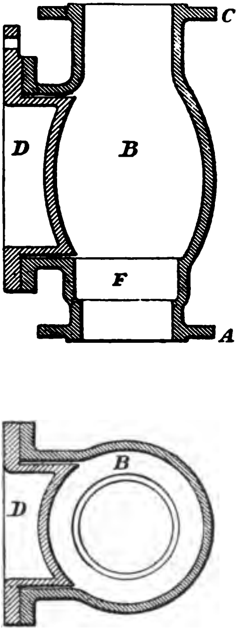
The valve-chamber or swelled part, B, of the clack-piece should be of ample area, or else the valves will bang. The area should be equal to the area of the valve-top-plate, plus the area of the water-way through the seat—that is to say, the annular space round the valve should be equal to the area of the water-way.

It is not necessary, in fact it is not good, to keep the annular space higher than the top of the valve when in its highest position; above that point, as shown in the illustration, Fig. 48, there is no more space required than the area of the working-barrel, but this reduction must be done gradually, so as to lead the water into one solid column to prevent any possibility of causing any shocks.

Another good shape of clack-piece, having the sides curved instead of straight, is illustrated in sectional elevation Fig. 49, and sectional plan Fig. 50. The object of this shape is to reduce the clearance space and add strength. This construction is used for valves with perpendicular lift, where the space round the valve is not required so large on account of no hinge being necessary on the valve, as is the case with the clack-valves. It will be seen from the illustration that the valve-chamber, B, is the same diameter at the bottom as the outside diameter of the valve-seat, then gradually enlarged to the required diameter, and again gradually reduced to the diameter of the working-barrel, or plunger-case, as the case may be.

The clearance spaces should always be reduced to a minimum. This is effected in various ways, both by the shape of the clack-piece, as has just been described, and by filling up the space with wood or casting the door so as to fit the internal contour of the clack-piece, as illustrated at D, Figs. 49 and 50. The latter plan, although frequently adopted, has the objection that the door becomes heavy and difficult to handle.

FIGS. 49, 50.



Great care should be taken to round all the corners inside the castings, and the outside radius should be struck from the same centre, as shown in Fig. 52, so as to give equality of metal, not as illustrated in Fig. 51, because, as it is stated in Anderson's "Strength of Material," "it has been found that all such irregularities introduce elements of discordance into that which would otherwise be the harmonious and natural order of crystallisation, any departure from which is always accompanied by corresponding weakness." The author has seen several clack-door-pieces and H-pieces, besides many donkey-pumps, which have cracked in working and during testing, at the corners, on the line A, B, Fig. 51, on account of their being made the wrong shape.

It is better to make the clack-piece, bucket-door-piece, and H-pieces *thick enough without ribs*, being more easy to mould and ensure a sound casting; but the flanges should always be provided with a rib or bracket between every bolt.

All *holes* in the *flanges* and doors should be cast-in, and made at least $\frac{1}{8}$th of an inch larger each way than the diameter of the bolts, and they should be $\frac{1}{8}$th of an inch longer than the width. Usually, for large pumps, the holes are made $\frac{1}{4}$ of an inch wider than the diameter of the bolt.

The *door-way* should be of ample size to get at the valve easily.

The *doors* should be provided with *lugs* to hold them up when removed and replaced. The best plan is to have the lug, on the clack-piece door on a plunger set, at the top of the door, as illustrated at E, Figs. 29 and 30, and on the face of the **H**-piece door, as arranged at E, Fig. 41, so that the chain and shackle will clear the clack-piece and door, D, and the projecting bolts and nuts.

FIG. 51.

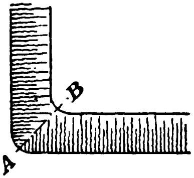
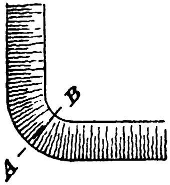


FIG. 52.



The *seat* for the valve or clack should be *bored out* $\frac{3}{8}$*ths of an inch larger* than the outside diameter of the clack-shell or seat, the latter being wrapped by tar-band about $\frac{1}{4}$ of an inch diameter; some pitmen prefer $\frac{3}{16}$ths of an inch thickness of leather, stitched together and pressed into the seat.

*Spigot* and *socket joints* in the clack-pieces and **H**-pieces, at G and H, Fig. 32, are very good to keep the joints tight, and all in a line, but they entail a lot of labour when the parts have to be taken apart in case of alterations or repairs.

*Projections* on the *inside* of the *door*, shown at J, Fig. 32, are convenient for removing and replacing the door; it should be made a very slack fit, or else there will be a difficulty to remove the door when it has been secured a long time, and it is more expensive to plane the facing strips.

Planed *facing strips* on the doors of clack-pieces are convenient, for if the door or joints should set fast, wedges can be driven in at the space left by the two facing strips.

It is by far the best plan, for the flow of the water, to *arrange the* H-*piece* as shown herewith in Fig. 41, namely, to have the windbore and clack in a direct line with the plunger case; but the usual method is the one illustrated in Fig. 43, that is, having the windbore, suction, and delivery-clacks, and rising-main all in one line.

The *length* of all the clack-pieces and H-pieces should be *faced* to *standard lengths*, so that a new piece will be sure to fit in the place of an old one, without having to supply the maker with a gauge.

## WORKING-BARRELS AND PLUNGER-CASES.

### WORKING-BARRELS.

The working-barrel or pump cylinder for a bucket-lift usually consists of a plain pipe, B, having a flange at each end, A and C, as illustrated in Fig. 53, which is, in this case, 21½ inches diameter. This pipe is bored true and parallel, and made larger at both ends, A and C, or, as it

FIG. 53.

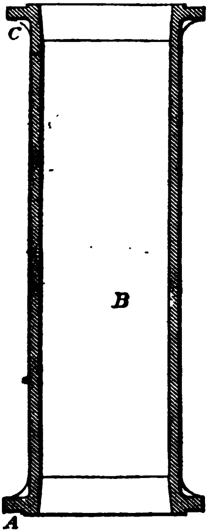


FIG. 54.

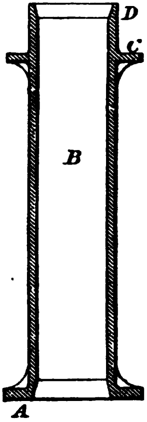
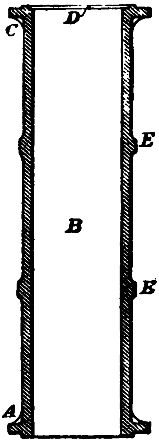


FIG. 55.



is technically called, "bell-mouthed," so as to allow the bucket to enter easily, without any danger of damaging the bucket-leather. The barrel is secured between the clack-piece and the bucket-door-piece, or the pump-trees or rising-main, when no bucket-door-piece is used. Some makers cast strengthening bands or hoops round the barrel, but that is a plan which should not be adopted, the casting being apt to be spongy on the inside, opposite the bands; therefore it is better to make the metal in the barrel thicker, and do away with the bands, although the bands are very useful, when the barrels have to be lowered, to rest the chains against, or the clips, by means of which they are held in the shaft.

Fig. 54 is a sectional elevation of a 12-inch working-barrel, fitted with a long spigot at D, which enters into the bucket-door-piece, as already mentioned on page 25, in connection with the bucket-door-piece.

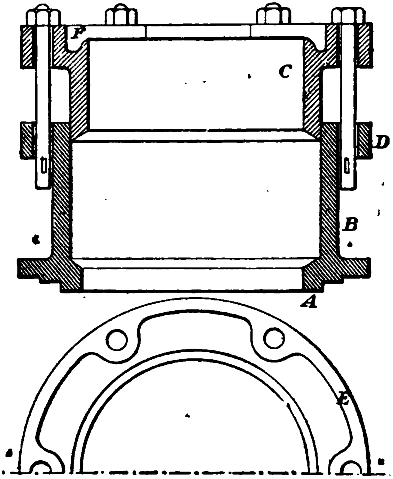
## PLUNGER-CASE.

The plunger-case is the name usually given to the working-barrel for plunger-sets, in which the plunger works without touching the sides, hence the barrel is not bored.

Fig. 55 is a sectional elevation of a plunger-case for a 20½-inch plunger, 8 feet length of stroke, 2 inches thick, for a 40-fathom lift, the stuffing-box being cast separate, which is generally the practice in large pump work, the gland and stuffing-box for this plunger-case being shown to a larger scale in Figs. 56 and 57. Fig. 56 is a sectional elevation, and Fig. 57 a half plan. In this case, it will be seen that there are two belts, E E, cast round the body, and there is a socket formed at D into which a corresponding spigot is cast on the bottom of the stuffing-box at A.

The only part machined on the plunger-case is the socket, D, when used, and the facings on the two flanges A and C, the body, B, being left rough from the trimming-shop. Referring to the sketches, Figs. 56 and 57, A is the spigot on the bottom flange; B the stuffing-box; C the gland, the flange of which and the flange, D, on the stuffing-box, are, as is the custom in large pumps round, with six cotter bolts or studs. In small pumps they are made square, having four bolts or studs, as illustrated in Fig. 14, page 11, in connection with the glands and stuffing-boxes for sliding windbores. In very small pumps the gland is oval with two bolts or studs. It will be observed that a deep rim E (Fig. 57) is cast round the top side of the glands to form a cistern for water, to prevent air from being drawn into the plunger-case; also a boss, F, round

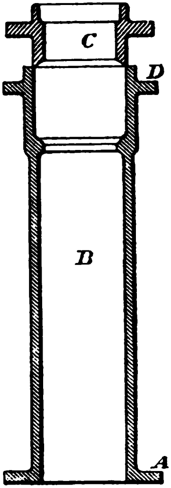
Figs. 56, 57.



the plunger, to prevent dirt and sludge from getting to it, forming, as it were, a settling cistern.

Fig. 58 is a sectional elevation of a 6-inch plunger-case with the stuffing-box cast on it; this is the usual plan adopted for small plunger-cases. The reference letters correspond with those on the previous illustration.

FIG. 58.



When plunger-pumps are working against heavy pressures the ordinary gland and stuffing-box, with hemp packing, cannot be used; in such cases the hydraulic leather packing is resorted to. These packings are made in different ways for different arrangements and different degrees of pressure. For very small plungers, the packing shown in Fig. 59 is usually adopted; A is the plunger, which has a groove turned into it at B; a narrow strip of leather, about ¼ of an inch wide, cut at an angle at each end, is carefully inserted, so as to perfectly fit into the groove. This is the cheapest and simplest form of hydraulic packing mostly used for hydraulic press pumps. Of course, when this packing is used the plunger must fit the working-barrel the whole of its length.

FIG. 59.

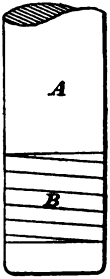


Fig. 60 illustrates the usual form of packing adopted for hydraulic press pumps, working against pressures of from 2 to 3 tons per square inch. The packing in this example consists of a *hat-leather*, B, placed at the bottom of a recess; on the top of the same is a gun-metal washer, E, the two being held firmly in their respective places by means of the screw gland, C. The washer, E, and the seat up to which the B is pressed, are provided with two grooves, turned by a diamond-pointed tool, so as to grip the leather firmly. The use of the washer, E, is to prevent the gland, C, from tearing the top surface of the leather when the gland is screwed home.

Some engineers are not satisfied with one hat-leather; they use two placed back to back, as illustrated in Fig. 61, the top leather, E, to prevent the air from entering the pump-barrel, and the bottom leather, B, for stopping the water from escaping round the plunger.

Fig. 60.

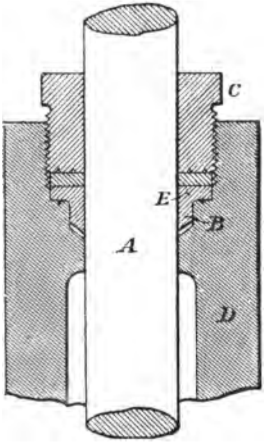
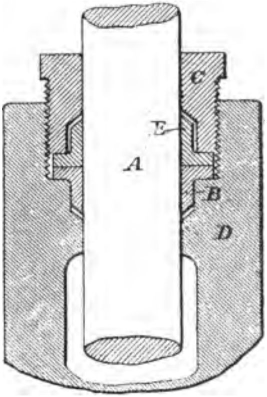


Fig. 61.



When the plungers are large the U-leather, shown at B, Fig. 62, is usually adopted. These leathers are arranged in various ways. In the case before us the leather ring, B, is inserted in a groove turned out of the top of the plunger-case, or cylinder; but great skill and care is required in inserting the leather in its place. A better and more convenient, though more expensive, plan is the one illustrated in Fig. 63, in which a gland, C, is provided and secured by means of screws or studs and nuts. When this plan is adopted the gland can be turned to fit the round shape of the top side of the U-leather, which greatly increases the life of the leather.

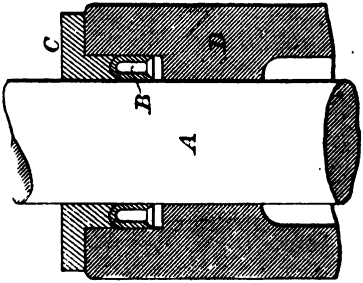


Fig. 63.

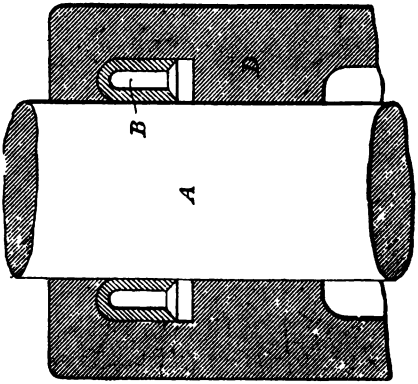


Fig. 62.

All these hydraulic packings are for single-acting ram pumps; when the pumps are double-acting there must be two leathers, one acting in each direction, as illustrated in Fig. 64. In this case A is the plunger or ram; B and C the two U-leathers; and D, working-barrel.

The method adopted by Mr. Henry Worthington, in his ordinary double-acting ram pump, is illustrated in sectional elevation, Fig. 65, and end view, Fig. 66; where A is the plunger; B, a plain bush, made of cast-iron or gun-metal, according to the class of liquid to be pumped; D is the working-barrel. Mr. Worthington claims the following advantages:—First, that the size of the plunger can easily be changed, either larger or smaller, by putting in a fresh bush bored out to the required size of ram; second, that there is an advantage to have no packing, as the plunger always wear most in the middle; hence, if there is a stuffing-box and the packing tightened a great amount of friction is created, which amount will more than compensate the loss of leakage of water round the plunger. This is of course a matter of opinion; the author is of the conviction that the leakage is a very bad thing, and

FIG. 64.

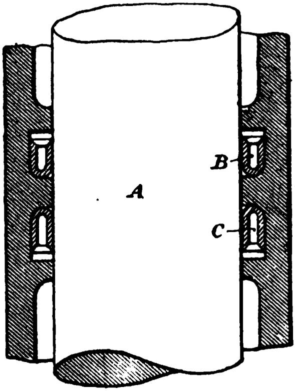
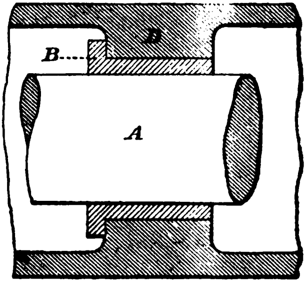


FIG. 65.



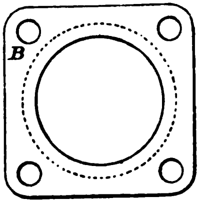
all precautions should be taken to prevent it; hence, internal glands and stuffing-boxes should be avoided; all should be external, so that any leakage can at once be detected.

## REMARKS ON DESIGNING WORKING-BARRELS AND PLUNGER-CASES.

The *bell-mouth* in the working-barrel for bucket-lifts should always be at the largest diameter, the same as the diameter of the pump-trees, or "pumps," as some Cornish pitmen call them.

Working-barrels and plunger-cases should, as far as possible, have *equal thickness of metal* all through, to ensure perfect sound castings; but where this is impossible, as with the flanges, which must be made thicker than the body, there must be large roots or hollows put in.

FIG. 66.



All *flanges* should have a *bracket* or *rib* between each bolt-hole, for heavy pressures or where there is any weight to be supported by them. All *holes* should be *square* and cast in the flanges, and large enough for the bolt to enter easily.

The *bolts* should have *square heads*, *nuts*, and *necks*, as the spanner gets a better grip on a square nut, and the square neck prevents the bolts from turning round when the nuts are tightened.

*Plunger-cases* are generally cast in one with the stuffing-box up to 7 inches or 8 inches diameter plungers; above that the stuffing-box ought to be cast separate.

*Flanges* on the *glands* and *stuffing-boxes* are made square, with four tightening cotter bolts or studs, with a nut underneath, up to about 12-inch plungers; above that they are made round, and have six cotter bolts. In no case should ordinary studs be used, because, in case one should break, a great delay is frequently caused, and in many instances great damage done to the workings in mines and coal pits.

A rim forming a *cup* or *cistern* should always be provided *upon* the *gland*, when the pump is vertical; in horizontal pumps there is, of course, no need for it.

## PLUNGERS OR RAMS.

The plungers or rams are made in various ways, and many different methods are employed for securing them to the spears or rods, a few of which will be illustrated and described in this section.

FIG. 67.

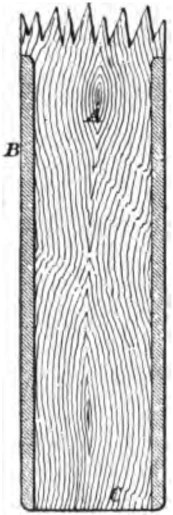


FIG. 68.

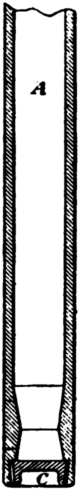
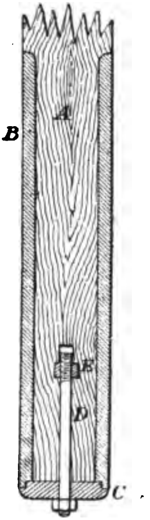


FIG. 69.

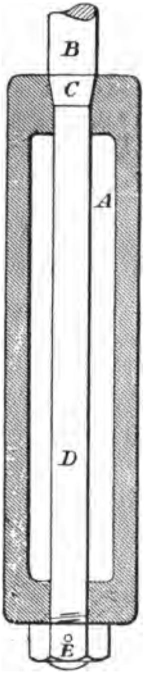


The first is one of the style mostly adopted in Cornwall, in the Cornish pit work, for an 18-inch plunger set, and is illustrated in Fig. 67. A is the wood plunger pole, or bottom end of the spear, driven tight into a cast-iron cylinder, B, and wedged tight by soft-wood wedges; the cast-iron liner or cylinder, B, being turned true and parallel on the outside, the bottom end, C, being left open to the action of the water.

A 6-inch plunger, with the bottom end closed by a plug, C, is shown in Fig. 68. This plug or end cover is secured to the plunger either by soft-wood wedges or caulked with rust cement.

Fig. 69 is a wooden plunger pole, A, covered with a cast-iron pipe or tube, B, and the washer or cover is secured by means of a bolt, screwed into a nut, E, let into the spear, A, before the case, B, is driven on the spear, A.

FIG. 70.



The method adopted by different makers of pumps for securing the plunger to the rods of direct-acting steam-pumps are very numerous. One method is illustrated in Fig. 70. A is the cast-iron plunger, B the pump rod, C is a taper fitting with a corresponding taper in the plunger, the small diameter of the rod, D, passes through the whole length of the plunger, and is secured by a nut, E. Some makers have the rod parallel, and a gutta-percha ring placed in a hollow provided between the enlarged part, B, of the rod and the plunger, or ram, A, to make the water-tight joint, instead of having the taper part, which latter is more expensive to bore.

Another method is illustrated in Fig. 71, in which there is a boss, D, formed at the cylinder end of the plunger, A, and the rod, B, made slightly taper and secured to it by means of a cotter, C.

In Fig. 72 the rod, B, is screwed into the plunger, A, and prevented from getting loose by a taper pin, C.

Again, in some cases, for moderate sizes of rams, a collar, C, is forged on the rod, B, and fixed in its place by a nut, D, outside the plunger, A, at the end farthest from the cylinder; but a better plan is to have a nut instead of the collar, C. A cotter or split pin should be provided behind the nut, D, also one through the nut at C, if one is used instead of the cotter. This is illustrated in Fig. 73.

FIG. 71.

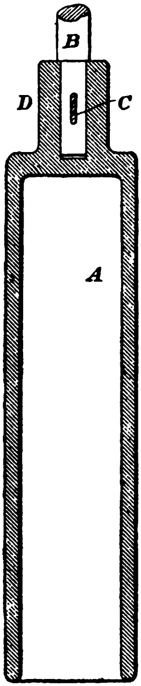


FIG. 72.

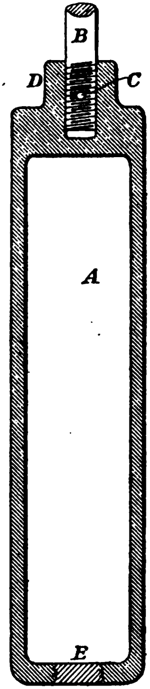
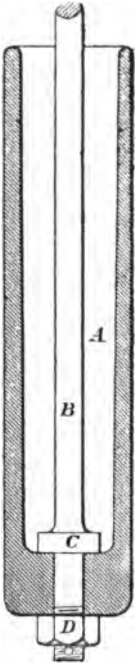


FIG. 73.



When the rams are very small in diameter, they are frequently made of wrought iron, Müntz-metal, or phosphor-bronze, in one piece with the piston or pump-rod.

The construction of the plunger, and the method adopted for securing it to the wrought-iron spears, in the forcing or plunger set at Saarbrücken, is rather peculiar.

FIG. 74.

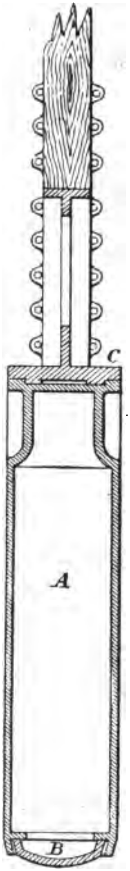


FIG. 75.

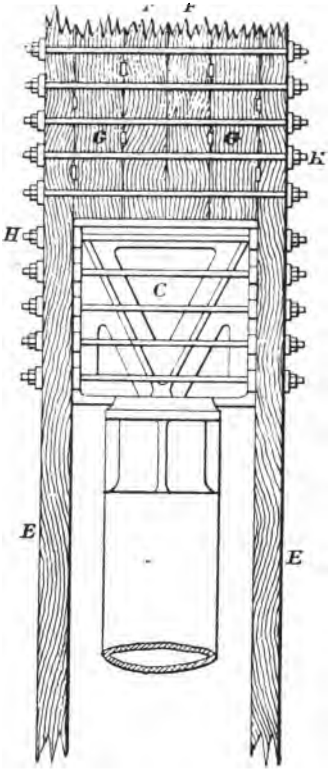
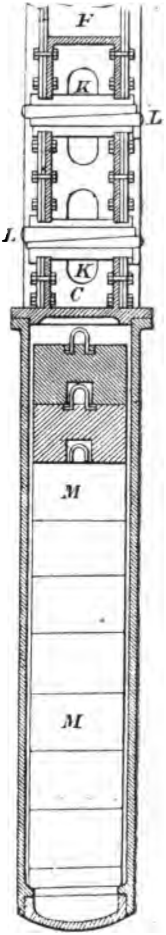


FIG. 76.

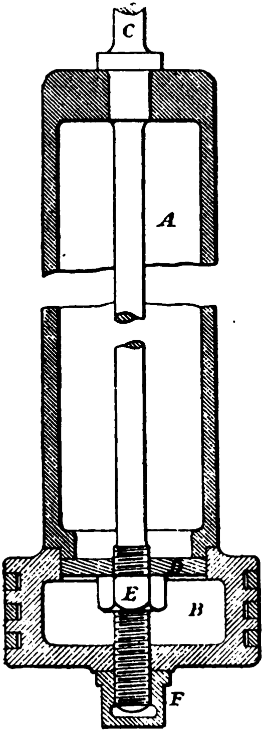


It is illustrated in sectional elevation Fig. 74, and front elevation Fig. 75. A is the body of the plunger; B the plunger bottom, secured in its place by soft-wood wedges; C is the cross-head, secured to the top of the plunger by bolts, D; this top is made of such width that the two spears, E, one on each side, clear the sides of the pump, the spears, E, passing down to the pump or pumps below; F F are the main spears, and G G two set-offs, all the wood-work being held together by the bolts, H H, and glands, J J.

A plunger with a connection like the previous example, but used for wrought-iron built-up spears, is illustrated in Fig. 76; the cross-head, C, in this instance is made longer and narrower, the wrought-iron spear, F, being secured to the cross-head by means of bolts and held rigid by double gibs, K K, and cotters, L L. The plunger in this case was weighted, the weights, M M, being placed inside the plunger.

## PISTON AND PLUNGERS.

FIG. 77.



The methods by means of which the pistons and plungers in piston-and-plunger-pumps are secured to one another are very numerous, therefore we must confine ourselves to a few examples of those mostly used. One arrangement is illustrated in sectional elevation Fig. 77, in which A is the plunger, B the piston, fitted with three brass packing-rings; C is the bottom part of the pump-rod, made of wrought iron. The procedure of securing the plunger and piston is as follows: first, push the rod through the ram, then put the wrought- or cast-iron plate, D, on the rod and secure that firmly by means of the nut, E, which latter ought to be made of gun-metal or brass; next put on the piston, B, and secure that by the nut, F, which latter is made solid-ended to prevent any water from leaking through, round the screwed part of the rod. The object of the plate, D, and nut, E, is to hold the plunger, A, fast on the rod, C, when the piston is removed. In this example the plunger was 11¼ inches diameter, and the working-barrel into which the piston worked was 16 inches diameter. The rod above the plunger was 2¼ inches diameter, through the boss at the top of the plunger 2½ inches diameter, the screwed pad at the bottom was 2¼ inches diameter, and the remainder of the rod inside the plunger 2 inches diameter.

FIG. 78

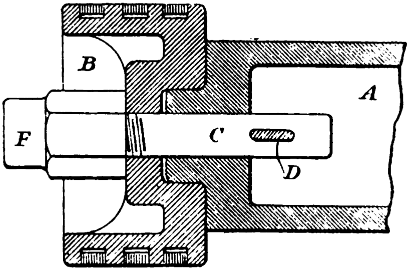
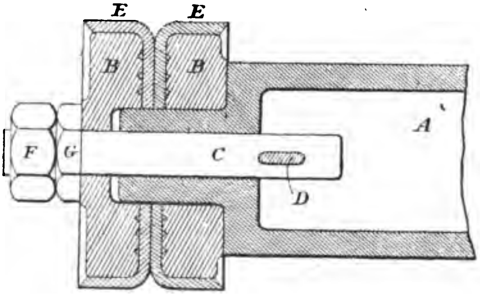


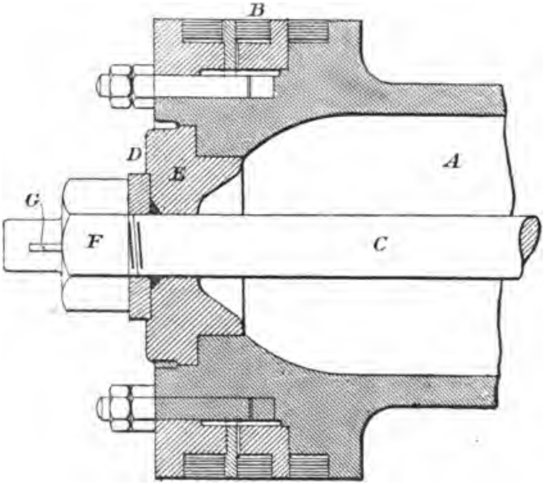
FIG. 79.



We have again illustrated in Fig. 78 a section of a small piston and plunger arrangement, where the plunger, A, is 4 inches diameter, and the piston, which is fitted with brass packing-rings, is 5⅝ inches diameter. Instead of passing the rod through the plunger, a cotter bolt, C, is used, which latter is secured into the plunger, A, by means of the cotter, D, and the piston is held fast to it by the solid-ended nut, F.

Another arrangement for the same pump as the previous example, but fitted with cup-leathers, E E, is illustrated in Fig. 79. Instead of the solid-ended nut, as shown in Fig. 78, there is in this case a nut, G, and lock-nut, F.

FIG. 80.



B B are the two piston plates fitted on to the projecting boss on the end of the plunger, to keep the whole true and central.

The last example we will allude to was made for a large set of sewage pumps, having a bore of 27¼ inches diameter, and the plunger 19½ inches diameter; the pump rod, C, was 4 inches diameter. This is shown in Fig. 80. A collar was formed on the rod above the plunger. A is the plunger, with the piston, B, cast in one with it; the whole at the bottom end of the plunger, for carrying the core while casting it, is closed by the plug, E, and the whole is securely held together by the nut, F, which latter is prevented from working loose by the cotter, G. D is a wrought-iron washer introduced between the plug, E, and nut, F, and a gutta-percha cord, ¼ of an inch diameter, is placed in a turned recess or chamfer to prevent any liquid from passing through into the plunger. The rings were made of the best gun-metal, 2¼ inches wide by 1 inch thick. The junk ring was secured by eight T-headed bolts, 1¼ inch diameter, fitted with nuts, lock-nuts, and split-pins.

## BUCKET AND PLUNGER.

The plungers for bucket-and-plunger-pumps are arranged on the rods almost in the same manner as previously described under the head of plungers.

The rod is extended below the plunger, in vertical pumps, and at the end farthest from the cylinder, or other driving power, in horizontal pumps.

The bucket is secured to the extended part of the rod, in any convenient manner suitable to the class of valve used, such a distance from the plunger as to allow the bucket-valve to lift the required distance. If the bucket-valve is of the single clack type, which is rarely the case, a fork, as illustrated in Fig. 104, is used; if butterfly-valve a sword is adopted, as shown in Fig. 106; and if there is a perpendicular lift valve, the arrangement in the bucket, Fig. 108, is resorted to.

## REMARKS ON DESIGNING PLUNGERS, PISTONS-AND-PLUNGERS, AND BUCKET AND PLUNGERS.

In some instances, when the stroke of the plunger is very long and where the transport is difficult the plunger and the plunger-case are cast in two or more pieces.

The rod should be arranged so as to make it impossible for the water, or other liquid raised, to pass through the ram from one end to the other.

The plan of screwing the rod into the plunger, as illustrated in Fig. 72, is very bad, as the rod will rust fast, and will consequently be difficult to remove when necessary.

The great advantage gained by cottering or screwing the rod into a boss, as shown in Figs. 71 and 72, is that there can be no communication for the water from one end of the plunger to the other, except by the stuffing-box, which can be tightened or repacked; no leakage can take place in any other way.

The plunger should be turned true, parallel and smooth, so as to work easily through the packing in the stuffing-box, or stuffing-boxes, if the pump is of the double-acting type.

If the water to be raised is impregnated with acid or other impurities, the larger sizes of plungers are covered with brass, gun-metal, or phosphor bronze, and the smaller sizes are of the same metal throughout; in the latter case they are cast as thin as possible, and well ribbed.

Open-ended plungers, as illustrated in Fig. 73, should always be avoided, because they increase the clearance space as much as the capacity of the interior of the plunger, which is, of course, equal in amount to the displacement of the plunger. When the rod is not passed through the plunger, a hole is cast through the back end or bottom end of vertical pumps for the core bar; this hole should be bored and screwed and fitted with a plug, as shown at E (Fig. 72), or the plug may be secured, as at C (Fig. 68), by wood wedges or rust cement.

When nuts are employed for securing the plungers on the rods, they should be made of brass or gun-metal.

Sometimes, in direct-acting steam-pumps, when there is plenty of room between the plunger and the end of the pump, the boss D (Fig. 71), into which the rod B is cottered, can be made long, but when the space is limited the boss should be made short, and the rod project into the plunger, as shown in Fig. 72.

For large pumps in shafts the plunger should always be a foot or two longer than necessary for the length of the stroke of the pump, to allow for inaccuracy in fixing the pumps in the shaft, the length of the spears, which, of course, cannot be guaranteed to a few inches, and to allow for the wood spears stretching when they are new.

The pin or cotter, E, for preventing the nut D (Fig. 70) from getting loose or for tightening up, should never be put through the nut, as in the illustration, but behind it, as in Fig. 73. The cotter is the best, as, if a draw is allowed, the nut can be turned very slightly round and still be tightened by the cotter.

The plunger in bucket-and-plunger-pumps and piston-and-plunger-pumps should always be made one-half the area of the bucket or piston.

The plunger should be carefully turned true and parallel, but in no case should the plunger be drawfiled, because, if they are finished in the lathe with well-defined encircling finish, three days' wear will give a dead polish which will last.

The plunger should be perfectly free from any blowholes, as they cause the packing to wear quickly, especially if leather packing-rings are used.

Wood wedges are far better and more convenient for securing the bottom plug in plungers than rust cement, as the latter is very difficult to remove when necessary.

# BUCKETS AND VALVES.

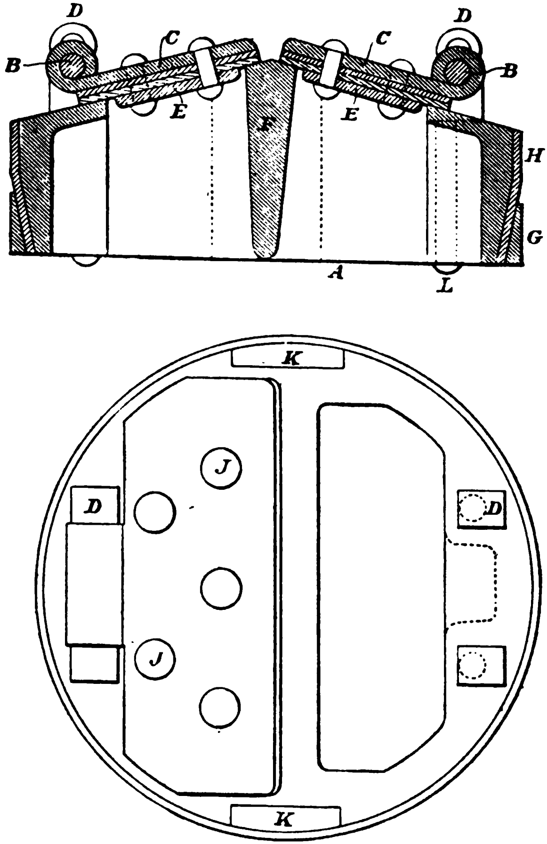
## BUCKETS.

The writer will here only refer to a few types of buckets and valves.

The bucket mostly adopted in mines and collieries, on account of their simplicity and the ease with which they can be repaired by unskilled men, is illustrated in Figs. 81 and 82. Fig. 81 is a sectional elevation and Fig. 82 a plan, in which the right-hand side clack is removed. A is the bucket shell or body, which is bevelled on the top, each way from the centre; B B are the pins on which the two clacks, C C, are hinged; the outer edges of these pins work in the four forks marked D, the holes being slotted, so as to allow the clacks, C, to lift perpendicularly before they commence turning on their hinges; E E are the bottom plates, with which the clacks and clack-leathers are secured together by means of rivets J, as shown, or preferably bolts with nuts and split pins. The forks, D, are riveted to the body on the under-side of it at L. H is a leather ring surrounding the bucket shell, and held fast by a turned wrought-iron ring G. The leather ring H usually consists of two thicknesses of leather fastened together by iron tacks, but the better plan, although seldom adopted, is to use soft wood pegs. K K are slots for the bucket fork, or bucket prong as it is called in some localities, to pass through. This example was made for a 21½ inches bucket-lift, 45 fathoms head.

A gun-metal bucket fitted with a gun-metal double-beat valve, for a 10-inch diameter working-barrel, is shown in sectional elevation, Fig. 83, and half plan, Fig. 84. A is the bucket body; B the double-beat valve;

FIGS. 81, 82.



C an ordinary cup or L-leather, held in place by a gun-metal ring, D, secured by means of six screws, L. E is the bucket-rod, secured at the bottom to the shell by the nut, N, and held against a steel collar, M. This collar is made conical on the underside to fit a corresponding cone bored out in the shell. The valve, B, is secured to the boss, which slides on the rod E, by six ribs, which are put at an angle, so as to compel the valve to partially rotate

Figs. 83, 84.

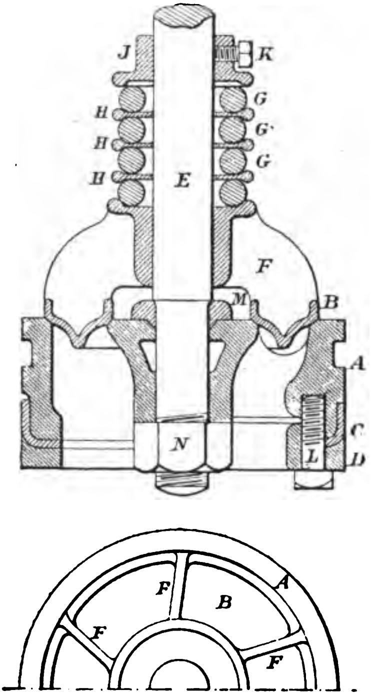
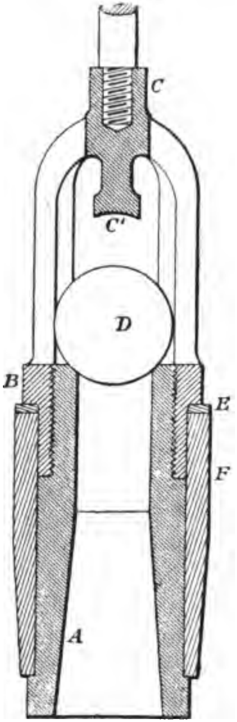


Fig. 85.



every time it rises, and so to keep the seats smooth and assist them to wear evenly. G G G G are four india-rubber rings, and H H H three gun-metal or cast-iron washers, the former preferred, which rings act as buffer springs, to prevent the valves from knocking when they rise against the stop J. They also assist the valve in closing gradually as the pressure in the working-barrel decreases, and to shut quickly at the end of the stroke without banging the seat. The stop J is made loose and is secured by the set-screw K, so that the lift of the valve can be regulated as desired.

FIG. 86.

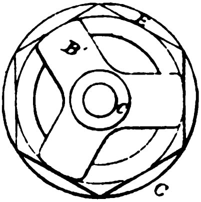
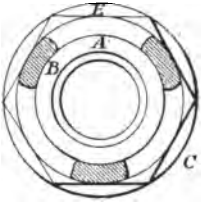


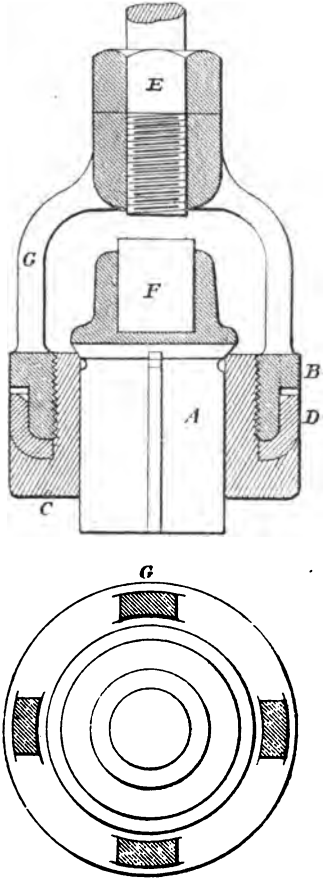
FIG. 87.



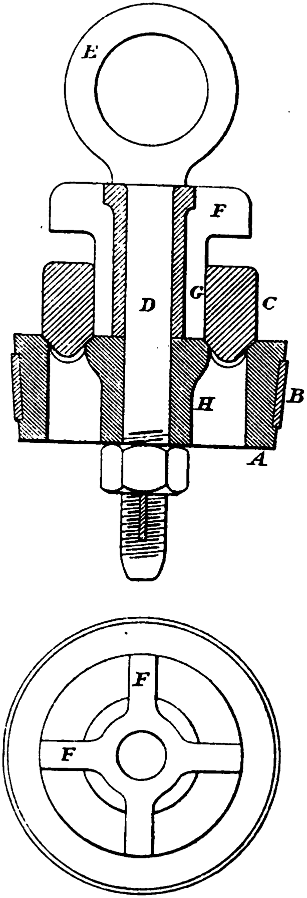
The next bucket we will refer to is for a 3-inch diameter working-barrel, and is fitted with a ball-valve. It is illustrated in Figs. 85, 86, and 87. Fig. 85 is a sectional elevation; Fig. 86 a plan; and Fig. 87 a section showing the three ribs, B¹. The packing F in this case consists of a leather ring, not a cup leather, which is put on the bucket-body A. To hold the leather F secure, the body is screwed at the top end, and furnished at the bottom with a shoulder. On the screwed part is screwed a hexagon-shaped ring, B. Between the ring B and the leather is placed a wrought-iron or gun-metal ring, E, so that when B is screwed down the leather is pressed between the shoulder on the body A and the ring E.

The seat for the ball-valve D, which latter is made either of brass, gun-metal or india-rubber, is formed in the body, A, and is guided by the three ribs or arms, $B^1$. These ribs join the ring B with the boss C. In the latter,

Figs. 88, 89.



Figs. 90, 91.



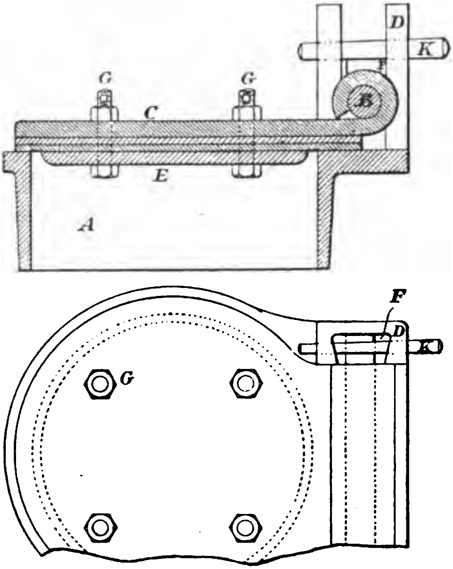
the bucket-rod is screwed or cottered. Under the boss C, is formed the stop $C^1$, which regulates the lift of the ball.

The last pump bucket the writer will refer to is fitted with an ordinary mitre-valve, and was made for a 2-inch bucket-lift. A is an ordinary mitre-valve, working in the bucket-shell C; D is the cup-leather, securely held between a collar formed at the bottom of the bucket-shell C, and a rim screwed on the top of the screwed part of the bucket-shell. The boss into which the bucket-rod is screwed and secured by a check-nut, E, is held together by the three ribs or arms, G. F is a piece of *lignum vitæ*, end way of the grain up, or a piece of india-rubber, to prevent the valve knocking when it rises against the end of the pump-rod, which forms the stop for determining the height of lift of the valve. This bucket is illustrated in Fig. 88, which is a sectional elevation, and Fig. 89 a sectional plan.

## PUMP VALVES.

A double-beat pump valve is illustrated in sectional elevation, Fig. 90, and plan, Fig. 91. A is the valve seat, surrounded by a leather ring, B, for making a water-tight joint between the valve seat and the seat provided for it in the valve-box, which latter is bored out to suit it; some engineers prefer tarred twine, $\frac{3}{16}$ to $\frac{1}{4}$ of an inch diameter, to the leather. C is the valve, which consists of a plain cast-iron or gun-metal ring, turned on the bottom side to fit the inner and outer beats on the valve-seat, which latter is also turned to receive the valve, usually to an angle of 45 degrees, though some few engineers prefer an angle of 60 degrees; G is a hollow boss, furnished with four or more ribs, F F, according to the size of the valve, secured to the valve seat, A, by the centre bolt or spindle, D, the screwed bottom end of which is tightened by a nut or cotter. The top part of the spindle, D, is furnished with a ring, E, the use of this ring being that the valve and seat can be drawn out from the top by a fish or catch, in case of repairs being required, when the clack-piece door is drowned—that is to say, when the water in the shaft or well has risen above the door, so that no access can be had through it. The reason why this valve is called double-beat is that the water, when it has passed the seat, A, passes both round the circumference of the valve and through the centre round the boss, G The four stops, F F, regulate the lift of the valve.

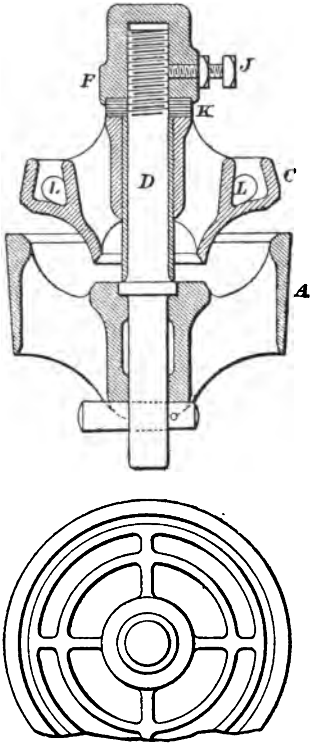
Figs. 92, 93.



Figs. 92 and 93 represent a sectional elevation and a plan respectively of an excellent clack for large plunger-sets and bucket-lifts, very common in the Cornish mines. It consists of a shell or seat, A, on to which are cast two horns or guides, D D; in these guides are fitted gun-metal bearings, F F, in which the clack-pin B moves up and down. It is clearly shown in plan, Fig. 93, that the bearings, F F, are dovetailed into the guides, D D. C is the clack, made of wrought-iron, and the hinge part is not forged solid, but is simply turned over a mandril, so that, in case the pin should wear, the hinge can be closed to fit it. E is the bottom plate, and that plate, the leather facing, and the clack are held together by bolts or rivets, G G. The valve is allowed to rise perpendicularly, for this size of valve (12 inches diameter water-way), 1¼ of an inch, before it commences to turn on the pin B. The gun-metal blocks, F F, in the guides, D D, are held down, and the amount of lift of the hinge-pin, B, is determined by the cotters, K K, which latter should be a good fit, so that they can be secured or released by a slight tap with a hand-hammer. The leather facings consist in the example before us of two pieces of leather, each $\frac{5}{16}$ of an inch thick. The usual way is to make the leathers round discs. This is an error; they should extend to the centre of the pin, because the heel soon wears off. If they were only discs the beat would soon disappear altogether on the hinge side, and the valve or clack become leaky. Vulcanised fibre has been used for facings with much success; when used with some water it lasts much longer than leather, and is cheaper in first cost. The clack-seat for large pumps should be made as light as possible for ease in handling.

Another double-beat valve of gun-metal is illustrated in Figs. 94 and 95. A is the valve-seat or shell, turned to receive the bored seat in the valve-chest; C is the valve; D the spindle upon which the valve, C, is permitted to slide

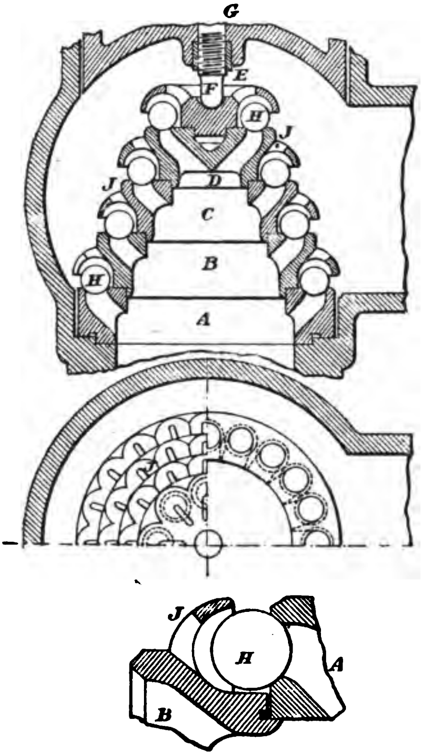
FIGS. 94, 95.



freely up and down to a height limited by the stop, F which can be adjusted to any desired lift and secured by a set-screw, J. The part of the spindle, D, on which the valve slides is covered with brass, when it is made of wrought-iron, but in first-class work the spindles are made of solid phosphor-bronze, and the spindle is secured to the seat by a cotter, not a nut, which is the usual practice. It will be seen that the two beats in the example are not in one line, as in Fig. 90; in this case the inner or smaller beat is below the outer or larger beat. It is clear that there is an easier flow for the water in this construction; but there is no doubt about it being cheaper in the manufacture to have both beats in one horizontal plane. The lift of a double-beat valve is usually made one-half of the lift for a single-beat valve. This valve was made for a 7-inch diameter plunger-set, and allowed a lift of $\frac{3}{8}$ of an inch. It worked well and so silently that its beat could hardly be heard when standing at the side of the clack-piece in the pit shaft. A leather or india-rubber washer, K, was placed in a recess provided in the underside of the stop, F, to prevent the valve from knocking at a hard substance when it arrived at the top of its lift. It is sometimes necessary to weight the valve. For that purpose is provided a chamber, L; in this chamber lead is cast to give it the required weight.

Multiple-beat valves are used for very large pumps. One of this type is illustrated in Figs. 96, 97, and 98. Fig. 96 is a sectional elevation, Fig. 97 half-plan, part of which is shown with the top seat removed, and Fig. 98 an enlarged section of one valve, seat, and guard. This valve consists of a series of ring seats, A, B, C, D, E, turned to fit one another, and securely held together by the screw, F, in the valve-box cover, G. The tops of the rings form the seats, and the bottom side of the ring above forms the guards. The valves are india-rubber balls, H, which are arranged in circles in the form of a pyramid, so as to afford a free entrance and exit for the water to each ring, without interference from the adjoining rings, each ball falling into a separate seat, as shown in plan, Fig. 97, and the enlarged section, Fig. 98. The joint between

Figs. 96, 97, 98.



each of the ring-shaped seats is made with a leather or gutta-percha ring, kept in its place by the nipple or bung provided on the underside of each seat. The bottom seat, A, is faced across and also provided with a groove for packing, but not turned on the side to fit the seat in the valve-box casting, as is the usual way of securing the seat. The valve guards, J, are shown plainly in plan, Fig. 97, and enlarged section, Fig. 98. A hole is formed in the top of each guard to facilitate the closing of the valve by the pressure of water on the top of the ball, preventing it from sticking to the guard.

## REMARKS ON DESIGNING PUMP BUCKETS AND VALVES.

All the beats and surfaces of contact between the metal valve and seats should be carefully ground together.

All ribs should be put at an angle, so as to compel the valve to partially rotate at each lift. The angle that has given the best results is 2½ inches in 1 foot.

The bucket-shell and valve-seat should be made as light as possible, consistent with strength, for ease in handling, especially in large valves for pit work.

The bucket should be made thin and the beat as narrow as practical, so as to give as much waterway through it as possible, to reduce the friction through the contracted space to a minimum.

Wood pegs should be used for uniting the double leathers round the bucket, Fig. 81, although it takes longer time to put them on the shell, as they wear better and do not injure the working-barrel face as the iron nails or tacks do.

The pins, B, in Fig. 81 and Fig. 92 do not require turning; they should be finished on the blacksmith's anvil.

In double-beat valves the area of the inside beat is generally made one-half the area of the outside beat.

For making the joint between the valve-seat and the seat in the clack-piece, tarred twine is preferred before the leather joint, but the twine should be carefully put on in even coils close together. Valves have frequently been drawn out and replaced several times without the necessity of renewing the twine, but leathers usually have to be put on fresh every time. The twine mostly used is $\frac{3}{16}$ of an inch diameter.

FIG. 99.

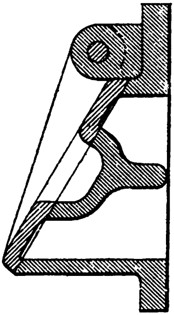


FIG. 100.

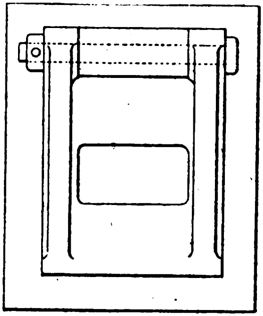


FIG. 101.

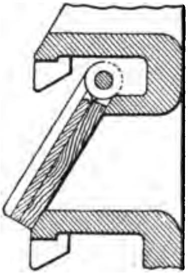
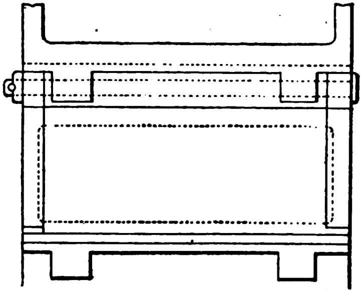


FIG. 102.



Metal valves without leather facings or soft beats are no good for mines, collieries, and any places where gritty and muddy water is met with, because any dirt coming under the hard seat will prevent them closing water-tight.

They also require regrinding very frequently, which process requires skilled labour, which generally cannot be found at mines or collieries.

A very common error in the designing of clack-valves is the position of the fulcrum or pin on which the valve is hinged. The usual plan is illustrated in section, Fig. 99, and elevation, Fig. 100, where the fulcrum is placed a distance above the valve-face, which causes the heel or the edge of the valve-face nearest the hinge to press against the valve-seat when the valve is closing, and consequently the valve will hang or stick open. It is evident that the further the fulcrum is from the valve-face the more likely the valve is to hang. To prevent this, the centre of the fulcrum should always be placed level or below the face of the valve, as illustrated in Figs. 101 and 102, which makes the part of the valve nearest the fulcrum come to the face simultaneously with the other part, hence there is an impossibility for the valve to hang from that cause. The author has found in practice several instances in which this has been the case, and had to design valves, as in Fig. 101, to replace valves like those shown in Fig. 99.

## PUMP-RODS AND SPEARS.

### Pump-Rods.

The pump-rods are made of wrought iron, steel, copper, gun-metal, phosphor-bronze, and Müntz-metal, according to the liquid or fluid to be raised, and the chemical properties of the water.

The sizes vary according to the diameter of the bucket or plunger, as the case may be, and the height to which the liquid has to be raised.

There is not any empirical rule for the diameter of the rod; it is found by calculating the total tension on the rod, which is the same as the total weight to be lifted, allowing 2 tons per square inch for wrought iron and 3 tons per square inch for steel.

Fig. 103.

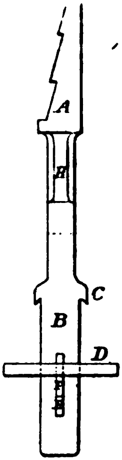
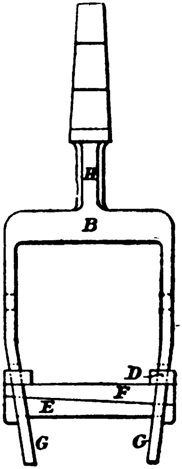


Fig. 104.



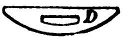


Fig. 105.

When the rod is used for forcing, the same diameter of rod as for tension will do, but the guides for the rod should be fixed closer together, never being more than 10 feet apart.

The rods are secured to the bucket in various ways, of which the following are the most commonly used. Figs. 103, 104, and 105 are a very common and good arrangement for buckets, as shown in Figs. 81 and 82. A is the bottom part of the knock-off joint, as it is usually termed; B is the fork or prong, the ends of which pass in the slots, K K, Fig. 82. C C are two shoulders forged on the two prongs, which shoulders rest against the top of the bucket-shell, A, Fig. 81. D is the half-moon shown in plan, Fig. 105. The object of these pieces is to hold the wrought-iron ring, G, and leather, H, Fig. 81, in their places. E is a gib and F a cotter for securing the half-moon, D, the gib and cotter passing through the bottom ends, G G, of the fork, B. H is the shank, which is usually octagonal in section.

In this example it is 3½ inches over flats, and the whole is arranged for a 40-yards bucket-lift, the bucket being 21½ inches diameter.

The method of securing the rod to a bucket fitted with an ordinary butterfly-valve is termed a bucket-sword, and is illustrated in Figs. 106 and 107. It was made for a 7½ inches diameter bucket-lift, and arranged for wrought-iron tube-rods, and a two-step knock-off joint, which will be explained further on under the head of "Knock-off Joints." In this case, instead of the fork it consists of a flat piece, F, termed the sword, furnished with a shoulder, C, resting on the valve-leather on the top of the bucket-shell, the sword passing through a boss formed in the centre of the shell; underneath the shell is driven a cotter, E, prevented from working out by means of a split-pin, H, D being a cross-bar placed between the boss in the shell and the cotter, E.

When the bucket is fitted with a valve of the type shown in Figs. 83 and 84, the connection is made as illustrated in Fig. 108. It consists of a plain spindle A, furnished with a collar C, and the bucket shell is secured between this collar and cotter E, or a nut N in Fig. 83.

FIG. 106.

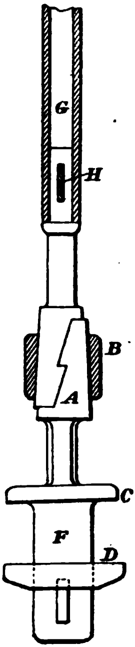


FIG. 107.

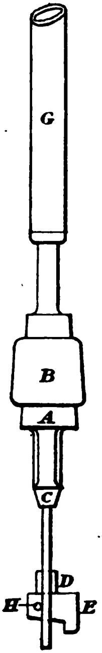
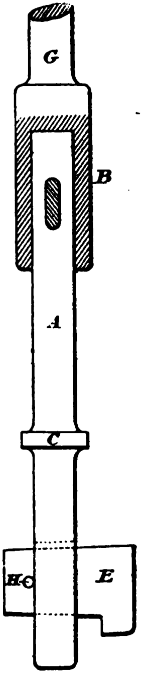


FIG. 108.



If the cotter is used it is prevented from working loose by the split pin H.

In small pumps the rod is either secured into the boss formed on the top of the bucket, and prevented from unscrewing by a split pin at C, in Fig. 85, or screwed into the boss and prevented from getting loose by means of a check-nut, as illustrated at E, Fig. 88.

## KNOCK-OFF JOINT.

The manner in which the pump rod is secured to the well-rods or spears, usually termed the "*Knock-off joint*," is accomplished in various ways.

The plan adopted, as a rule, in the Cornish mines, is illustrated in Figs. 109 and 110. A is the bottom half of the knock-off joint forged solid with the bucket-fork; D is the top half forged in one with the shank E, and

FIG. 109.

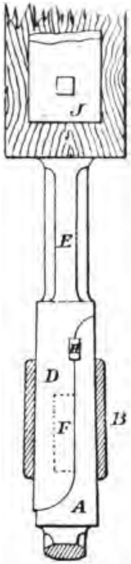


FIG. 110.

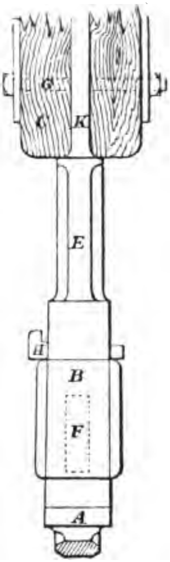


FIG. 111.

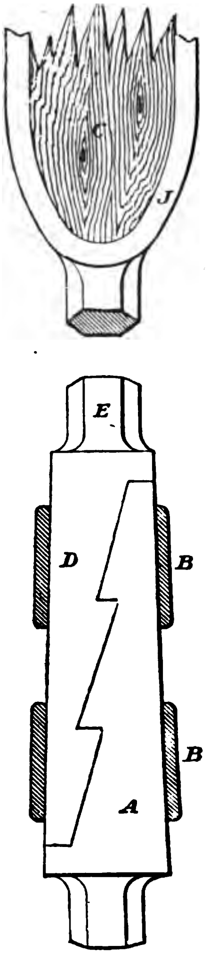
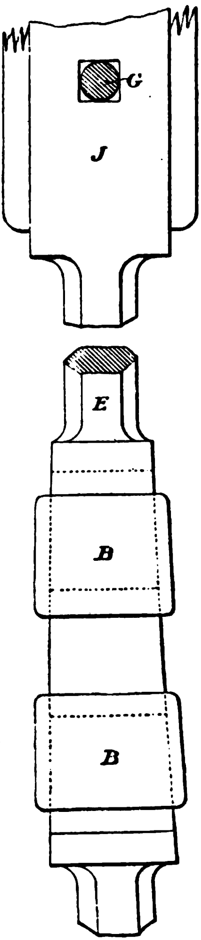


FIG. 112.



strapping-plate K. F is a key forged on the part A, and fitted into a recess in the part D; B is a sleeve, usually termed the clasp, which is driven tight on the joint, holding the two parts A and D together, and H is a cotter driven into D, just above the clasp B, to prevent the latter from working loose. The strapping-plate K varies in length and thickness, according to the size of the bucket and the height of lift. In this example the bucket was 24 inches diameter, 40 fathoms lift; the plate was 1$\frac{5}{8}$ inch thick at the bottom, tapering to $\frac{1}{2}$ an inch at the top, 8 inches wide and 7 feet long. A washer-plate $\frac{1}{2}$ an inch thick by 6 inches wide was placed on each side of the wood-spear, and the whole was held together by ten bolts 1 inch in diameter, with square heads, necks, and nuts.

Another knock-off joint, illustrated in Figs. 111 and 112, is very much used in collieries. The letters correspond with those in the previous example. In this case, instead of having one clasp, there are two hoops B B; the key in the part A is dispensed with; in its place three steps or off-sets are formed in the parts A and D. Instead of the centre strapping-plate inserted into the bottom of the wood-spears, a Y-piece or fork strapping-plate J, fitted to the bottom end of the wood-spear C, is used and secured by the bolts G.

For smaller pumps the knock-off joint is only furnished with two set-offs, as illustrated at A, Figs. 106 and 107. In that example the top part of the shank is secured to tube-rods G by means of a cotter H, against a cotter on the shank. A better plan is to screw the shank into the tube-rod C, and dispense with the cotter H.

A knock-off joint suitable both for pull and push, as is necessary for bucket-and-plunger and piston-and-plunger pumps, is illustrated in Fig. 113. It consists of the usual clasp or box C; A is the top rod; B the bottom rod. It will be seen that the set-offs are arranged equal on each side of the centre line of the joint, so as to ensure the same resistance either way. The example before us was made for rods 1¼ inch diameter, the joint was 2 inches square at the top and only 2¼ inches square at the bottom; this was too little taper, and there would be considerable difficulty in getting the clasp off, when the rods have been at work any length of time. The proper taper to be given to the knock-off joint will be given further on in remarks on the construction of rods.

FIG. 113.

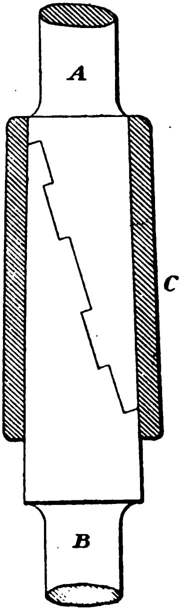


FIG. 114.

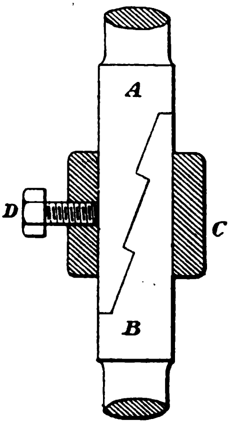
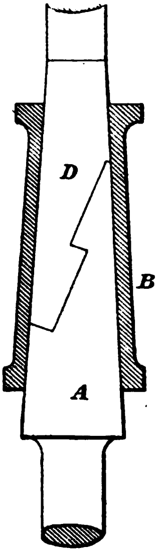


Fig. 114 illustrates a very simple rod- or spear-coupling and clasp, the coupling having three set-offs. In this case A is the top rod; B the bottom rod; C the clasp; and D a set-screw for securing the clasp in position. This plan is very cheap to manufacture, because the rod ends are parallel, which are easier to machine than the tapered rod-ends.

FIG. 115.

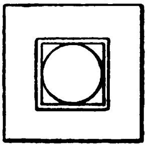


The knock-off joint, mostly used for deep-well pump rods, is illustrated in Figs. 115 and 116, and consists of two steps, the clasp or socket B being made of gun-metal in first-class work, because it will not set fast with rust, but for cheap work they are made of cast-iron or cast malleable iron.

Fig. 108 illustrates the ordinary socket B forged solid with the wrought-iron pump rod or spear G, the pump rod A being secured in the socket B by a cotter.

The manner in which the connection is made for bore-hole pumps, and sometimes in deep-well pumps, is shown in Fig. 117. The pump-rod A and the well-rod B are joined by the swell or boss C on the well-rod, the pump-rod being screwed into the swell and furnished with a check or back nut D.

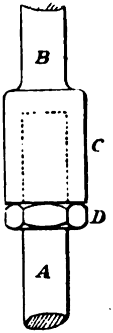
FIG. 116.



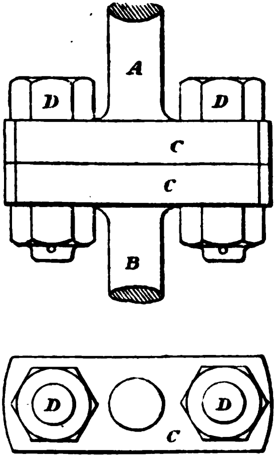
A simple, though not very good, method of coupling solid wrought-iron or steel rods together, is illustrated in Figs. 118 and 119; it consists in forging flanges C C on the ends of each length of rod; A is the top rod; B the bottom rod; D D are the bolts by means of which the rods are held together. The bolts, when bucket pumps are used, must be strong enough to lift the water besides sustaining the weight of the rods. Properly the bolts in the bottom rods ought, theoretically, to be made less in diameter than those at the top, because they have less weight of rods to carry, but for the sake of the rods being interchangeable, all bolts and ends are made, in practice, the same diameter.

Again, another arrangement for coupling solid wrought-iron rods together is illustrated in sectional elevation, Fig. 120, and sectional plan, Fig. 121. In this case the bottom rod A and the top rod B are furnished with collars C C, which should be forged solid with the rods. D and E are a pair of cast-iron or cast-malleable-iron clips, the latter being held firmly together by means of the four bolts F.

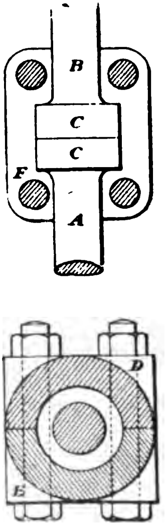
FIG. 117.



FIGS. 118, 119.



FIGS. 120, 121.

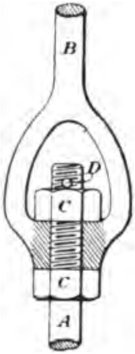


The usual manner in which the pump-rod and well-rod in small deep-well rods are coupled is shown in Fig. 122. A is the pump rod, B the well rod; the latter is formed at the bottom into a bow, in which the pump rod is screwed and provided with nuts C C and a split pin D.

## STRAPPING-PLATES OR ROD JOINTS.

The ordinary wrought-iron strapping-plates are illustrated in Fig. 123. They consist of wrought-iron plates B B, which should be made thick in the middle and taper down towards each end, so that the two outer ends are about one-half the thickness of the middle, although some, or I might justly say many, engineers make them parallel for the sake of cheapness in forging, having only to cut the bar-iron in proper lengths. The size of the plates must be calculated in the following manner:—The weight to be lifted in tons, divided by 2 = the number of square inches area required in the two or four plates, as the case may be. Allowance must be made for the area of the bolt-holes. The bolt-holes are usually punched square; round drilled holes have been punched square in the slotting and punching machine, but found to cost more money and not to be as good. Some engineers prefer round drilled holes, but they are objectionable, as already stated. Oft-times in practice only two plates are used; this is objectionable, for it only ensures rigidity one way. The best method is to have one plate on each side of the rod, as shown in Fig. 123, although it weakens the wood-spears, by the cross holes

FIG. 122.



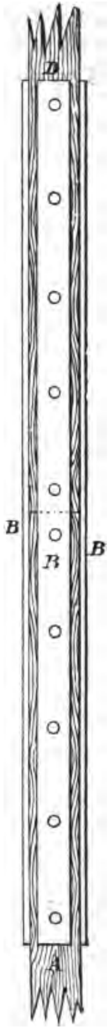
for the bolts; but as the spears are much larger, as a rule, than is necessary for the work, it need not be taken into consideration.

Sometimes cast-iron strapping-plates are used where weight is required, instead of wrought-iron. These plates must be arranged so that the bolts pass outside the wood-spears, the rod thus retaining its strength throughout. This arrangement is illustrated in elevation, Fig. 124, and plan, Fig. 125.

Amongst the number of different styles of strapping-plates, we find a very good, useful, although rather expensive one, illustrated in Fig. 126, which is frequently used abroad. In this illustration A is the wood-spear; B a pair of ordinary strapping-plates; C and D are another pair of plates of a different construction; they are made in two pieces, each hooked at one end, as shown at E and F, and a steel key or wedge is driven into the recesses formed by the hooks, the wood-spears being cut level across. When the spears are secured the pair of plates C and D are first firmly bolted to their respective wood-spears, the wedges driven in tight, so as to draw the spears firmly together butt to butt, then the holes for the strapping-plates B are bored and the plates secured in the usual manner by bolts and nuts.

It will be seen that in the method in joining the spears in the last example, the ends of the timbers are cut square across; in the example illustrated in Fig. 127, the spears A and B are scarfed together, and a key, C, driven in the

FIG. 123.



middle of the joint. This style is rather costly, as the scarf must be made carefully, so as to ensure a perfect fit and prevent any shake, although it is a very good plan. The strapping-plates are made in the ordinary fashion, the best plan is to have four plates, as has already been recommended, although frequently only two plates are used, as shown in Fig. 127.

Figs. 124, 125.

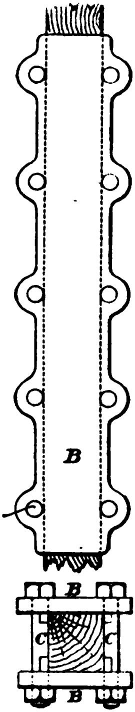


Fig. 126.

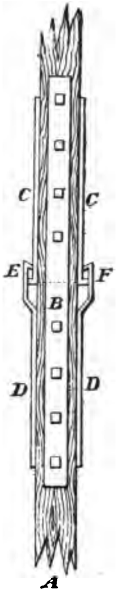
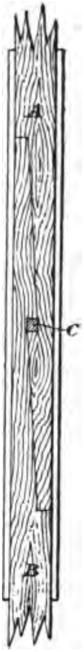
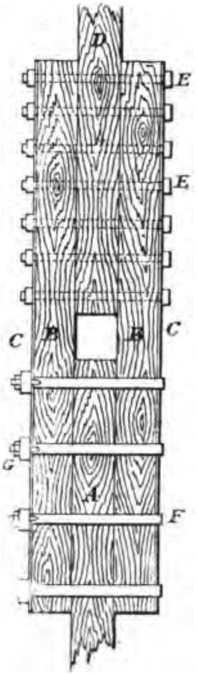


Fig. 127.



In some rare instances one set of strapping-plates, or connection between two of the spears, is made, as illustrated in Fig. 128. A is the bottom wood-spear, or in some cases the plunger-pole; C, C, two wrought-iron washer plates; E are bolts, by means of which the two pieces of timber, B, B, are firmly secured to the upper spear, D; F F are staples, and G glands, by which the spear A is held to the pieces, B, B. By this arrangement it will be seen that the total length of the spears can be lengthened or shortened, to allow for stretching of the new wood-spears or other adjustment which may be required.

Fig. 128.



One plan for joining the wrought-iron or steel well-rods is illustrated in Fig. 129. The bottom rod A and the top rod D are screwed, one right-hand and one left-hand, into the socket B, and a cotter C is inserted half into each rod, to prevent them from unscrewing.

Fig. 130 shows another method in which tube rods are joined. It consists of a round piece of iron, B, fitting the inside of the tubes A and D, and both secured to B by the cotters C C.

Solid iron rods are joined by any of the knock-off joints already described, by the socket C, Fig. 117, or the method illustrated in Fig. 130.

## Top Rods.

The usual way in which the top rod is coupled to the beam of a Cornish engine working ordinary Cornish pit-work, is illustrated in Figs. 131 and 132. A is the gudgeon; B the gun-metal bearing, which is only required for the top half, as the weight of the wood-spears force the water up, and the work really exerted by the engine is to lift the spears, hence all the wear is on the top, the bottom part of the gudgeon working in the top of the wood-spear; C is a cast-iron block into which the gun-metal step or bearing, B, is fitted; the block C is secured by the cotter D, and gib E. By means of the former any wear taking place can be taken up. F F are the main strapping-plates for securing the bearing to the wood-spears, and G G are two stiffening plates, the four plates being secured by bolts placed zig-zag and arranged so as to clear one another, as the cross in the timber.

Fig. 129.

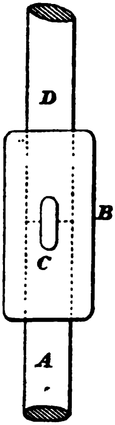
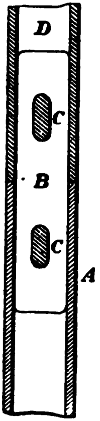


Fig. 130.



The common type of top rod for securing the wood-spears to L-bobs or T-bobs is illustrated in Figs. 133 and 134. In the example before us the gudgeon is 3½ inches diameter, and the wood-spear 5 inches square; therefore, the strapping-plates F F were straight on the outside. But sometimes the wood-spears are larger at H than at J, and all the bolts are of different length, and the wood-spears are cut taper towards J. A is the gudgeon, B the gun-metal steps, D the cotter, and E the gib. The bolts, as will be seen in Fig. 134, are placed zig-zag, so as not to cut the grain of the timber in a straight line. The strapping-plates F F are always

FIG. 131.

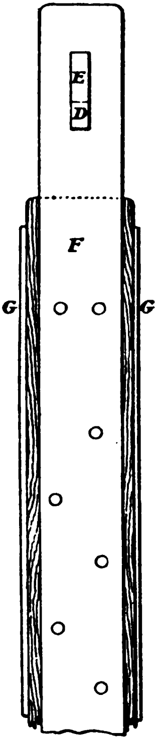
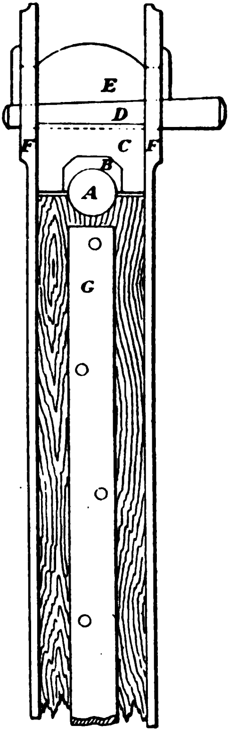


FIG. 132.



made taper from J to the end H, as the strain on them gradually decreases the further it gets from the gudgeon.

Some engineers object to the separate strapping for the top of wood-spears, as they require to be very carefully secured to the spears, so as not to get the two bearings on a twist; in such cases the bottom part of the rod is made Y-shaped. This type is illustrated in Fig. 135, in which A is the gudgeon, B the gun-metal steps, D the cotter, and E the gib; F F is the Y-piece,

Fig. 133.

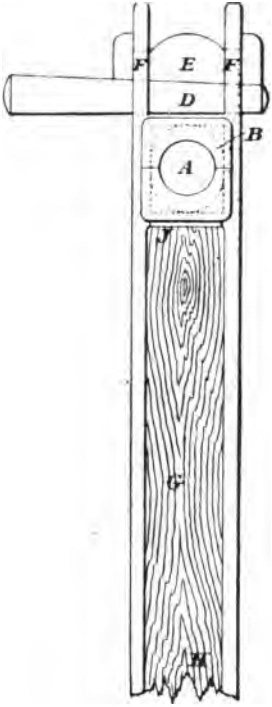
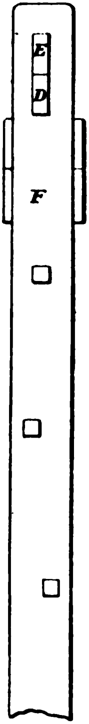


Fig. 134.



G the wood-spear. In this case the spear was made half-round at the top end; in other cases it is cut elliptical, as shown in Fig. 111.

Fig. 136 is a top rod for tube rods. It is mostly made exactly like the top part of Fig. 135, but instead of the Y-piece, the rod is furnished with a collar, H, and a shank underneath the collar is screwed to fit the internally-screwed top part of tube rods G. When these rods are made for a bucket-lift, the top half of the bearing is of gun-metal, the bottom part being of cast iron. If it is working a plunger-set, the bottom half is gun-metal, and the top cast iron; but if it is for a piston-and-plunger-

Fig. 135.

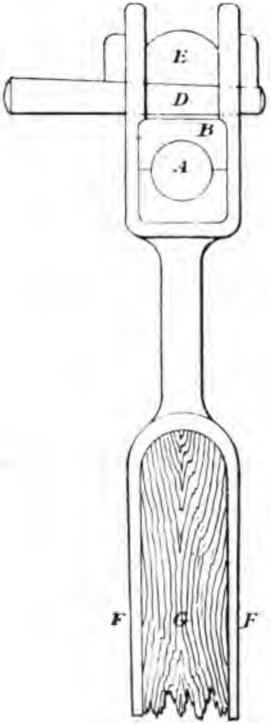
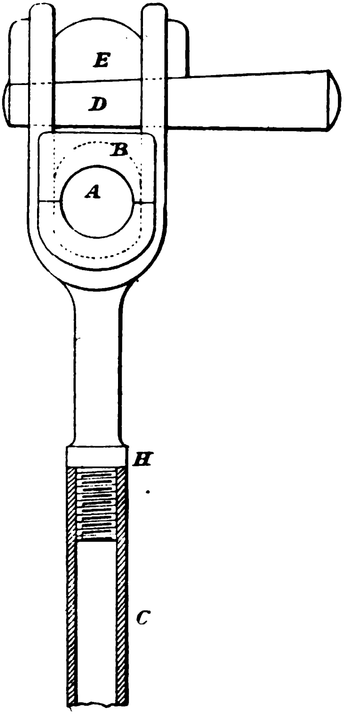


Fig. 136.



pump both top and bottom halves should be made of gun-metal.

Wrought-iron spears, built up of plates and angle- or channel-irons are frequently used on the Continent, but the author has not seen any in Great Britain. Two examples of these spears are shown in Figs. 137, 138, 139 and 140. Fig. 137 is a side elevation, and Fig. 138 a

FIG. 137.

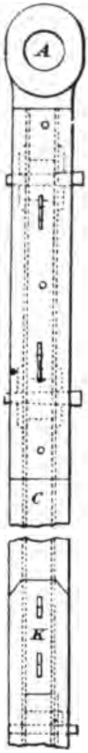


FIG. 138.

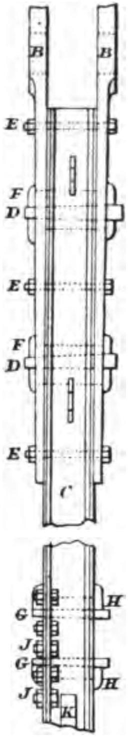


FIG. 139.

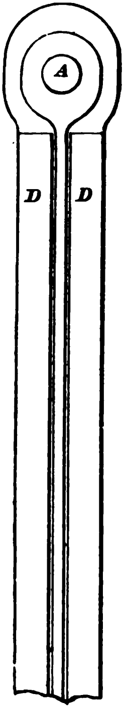
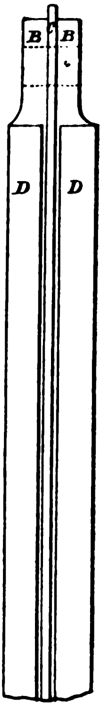
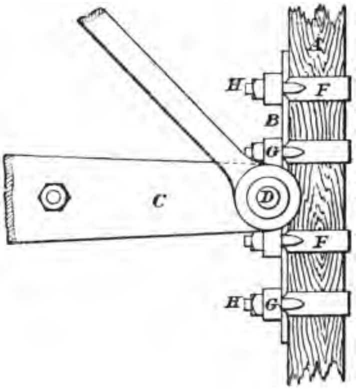


FIG. 140.



front elevation of one, showing the top rod and the manner in which the different lengths of spears are secured to one another. A is the gudgeon, B B two strapping-plates, C the wrought-iron spear, consisting of two channel-irons and two plates forming a box. The strapping-plates are bolted to the spear by the bolts E, and tightened up by the gibs F and cotters D. K shows the joint of two of the spears, J are the bolts, H the gibs and G the cotters, by means of which they are secured to one another.

Fig. 141.



Figs. 139 and 140 show a top of a wrought-iron spear of cross section. A is the gudgeon, B B are two forged cheeks, C the centre plate, the centre plate and cheeks being riveted together and held firm by four angle-irons D. The centre plate C and the cheeks B B gradually taper to a knife-edge, below which the rods consist simply of the four angle-irons, which are riveted to one another.

A very good method of securing the wood pump spears

A to the T-bob or L-bob, as the case may be, in well-sinking or small temporary pit or mine shafts, is illustrated in Fig. 141, in which A is the wood-spear, B a wrought-iron plate with a boss forged on it; in some cases it is made of cast-iron; the boss is bored to receive the L-bob, pin or gudgeon, D: the plate is secured to the spear by means of the usual staples, F, and glands, G.

FIG. 142.

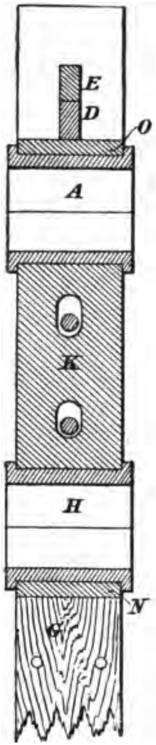
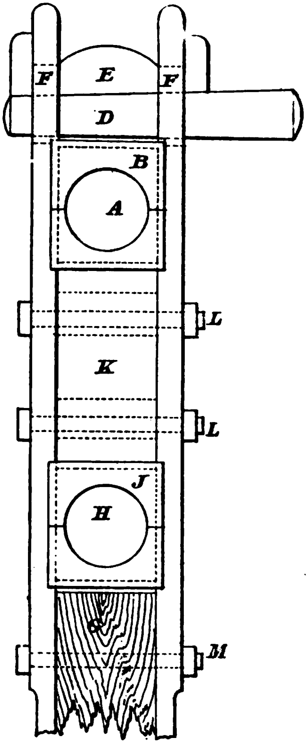


FIG. 143.



The spear, A, in this case is made any length decided to be used in the pit, and as the sinking is progressing the nuts H are slackened, the spear lowered down the required depth, when the nuts are again screwed up tight.

All these top rods are also suitable for horizontal spears working T-bobs or L-bobs. When there are two L-bobs worked by the same crank pin or horizontal direct-acting pumping engine, the rod nearest the crank or engine has sometimes a double journal, as illustrated in Figs. 142 and 143. Fig. 142 is a sectional plan, and Fig. 143 an elevation. A is the bearing for the gudgeon, which passes through the L-bob; B the gun-metal bearing or steps for the same; H is the bearing for the gudgeon, by means of which it is coupled to the second L-bob; J is the gun-metal steps for it; K is a cast-iron block, placed between the two bearings B and J, held in its place by the flanges on the gun-metal steps, and by the two bolts, L L, which pass through the slotted holes in the block, K, and prevent the strapping-plates, F F, from buckling; G is the wood-spear, which is held firmly to the plates, F F, by the bolts, M, which are pitched, about 12 inches apart, all the length of the plates; N is a wrought-iron plate placed between the steps, J, and the wood-spear, G, and O, another plate between the steps, B, and the cotter, D; E is a gib. It will be seen that the cotter, D, when set up, serves to tighten both the bearings, B and J, at the same time. The gudgeons in this example were 8 inches diameter by 12 inches long, rods being used for two bucket-lifts each 24 inches diameter, working from a depth of 700 feet. The strapping-plates are 24 feet long from centre of gudgeon, H, to the end; the width of the plates was 10 inches, and the thickness 2 inches at the bearings, tapering down to ¾ of an inch at the ends.

The end on the horizontal rod between the two L-bobs, which couples to the double journal end just described, is very simple, as shown in Figs. 144 and 145. It consists of two strapping-plates, F F, each of which is furnished at one end with a boss, A A, bored to fit the gudgeon, A, Fig. 143, the gudgeon being prevented from turning in the bosses by means of a small key fitted into one of the bosses, and the wood-spear or rod, G, fitted between the two plates. In the example

FIG. 144.

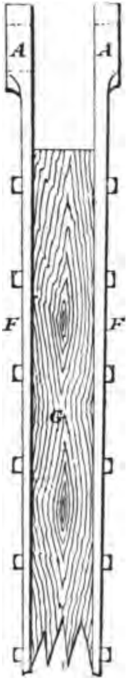


FIG. 145.

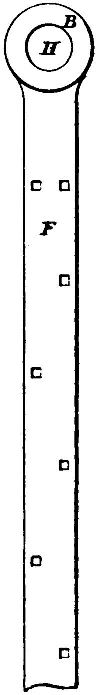
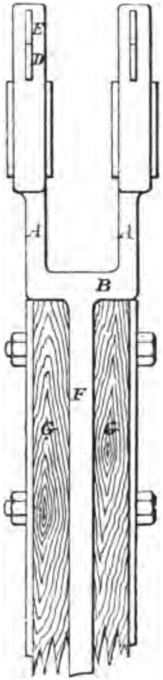


FIG. 146.



before us the distance between the two bosses, A A, was 12 inches.

The last rod we will consider is illustrated in Fig. 146. It is used when an ordinary single bearing rod, as shown in Figs. 133 and 134, is used to actuate one of the L-bobs, and consists of a single strapping-plate, F, passing up the centre of the wood-spear, G, in a similar manner to the one illustrated in Fig. 110, in connection with the knock-off joint and bottom spears. The ends, A A, are forged solid with B and F, the whole forming a fork; each of the two sides, A A, being fitted with gun-metal steps, gibs, E E, and cotters, D D, similar to Figs. 133 and 134.

## REMARKS ON DESIGNING PUMP RODS AND SPEARS.

The knock-off joints should be put on the fork the reverse way to that shown in Figs. 103 and 104, because, when the bucket is raised out of the pump-trees, to be disconnected, a piece of timber is put under the fork at B to hold it, and the bucket rocked to and fro, to separate the two parts, A and B, of the knock-off joint, in Fig. 113, and it will readily be seen that it is easier to rock it when the joint is placed at right angles to the fork. The knock-off joint should be carefully shaped to perfectly fit one into the other; all of them, in the same shaft, should be interchangeable, hence one or two kept in stock will fit any joint. Some makers do not shape the joint, they make one half and forge all the others to fit it, in the smith's shop, and do not machine them. This is a cheap way of making them, but it is not to be recommended.

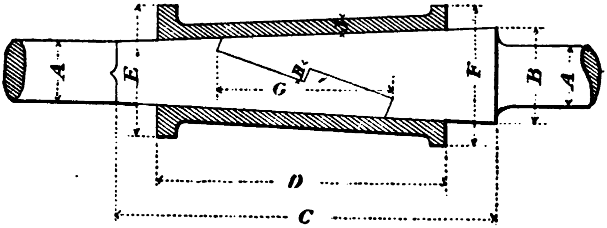
The taper of the knock-off joint varies greatly. Some engineers give a taper of one in eighteen, but one in twelve is a better proportion, because if the taper is too small, the clasp is liable to set very fast, and is consequently difficult to remove, when necessary, after it has been working a long time.

The single clasp or box, as shown in Figs. 109 and 113, is superior by far, and easier to work, than the two hoops shown in Figs. 111 and 112.

## TABLE I.

### KNOCK-OFF JOINTS WITH GUN-METAL CLASPS.

FIG. 146*.



| A | B | C | D | E | F | G | H | J |
|---|---|---|---|---|---|---|---|---|
| ⅝ | ¾ | 4¾ | 3¼ | 1¼ | 1½ | 2 | 3/16 | 3/16 |
| ¾ | ⅞ | 5 | 3½ | 1¼ | 1½ | 2 | 3/16 | 3/16 |
| ⅞ | 1 | 5 | 3¾ | 1½ | 1¾ | 2⅛ | 3/16 | 3/16 |
| 1 | 1½ | 5⅜ | 3⅞ | 1¾ | 2⅛ | 2⅝ | ¼ | 3/16 |
| 1⅛ | 1⅝ | 5½ | 4½ | 2¼ | 2½ | 3¼ | ¼ | ¼ |
| 1¼ | 2 | 6 | 5 | 2¾ | 2⅞ | 3⅜ | 5/16 | ¼ |

The holes in the strapping-plates and Y-ends are usually punched and square, somewhat larger than the diameter of the bolts. Some engineers prefer round-drilled holes, as they have the notion that punching weakens the strapping-plates, but in such cases two men are required to secure the bolts in their places, one to hold the head with a spanner when the other is tightening the nut.

The bolts for small spears, working in the pump-trees, are mostly made cup-headed, having square necks; for large spears square heads, necks, and nuts should be used, except, of course, when round-drilled holes are used, the necks must be made round instead of square.

## TABLE II.

### STRENGTH OF BOLTS.

Stress on wrought-iron bolts = 4480 lbs. per square inch.
Stress on steel bolts = 6720 lbs. per square inch.

| Diameter. | Area at bottom of thread. | Safe load for Iron. | Safe load for Steel. | Number of threads per inch. |
|---|---|---|---|---|
| Inches. | Square inches. | lbs. | lbs. | |
| ⅜ | 0·094 | 421·1 | 631·6 | 16 |
| ½ | 0·1213 | 543·4 | 815·1 | 12 |
| ⅝ | 0·2034 | 911·2 | 1366·8 | 11 |
| ¾ | 0·3038 | 1361·0 | 2041·5 | 10 |
| ⅞ | 0·4219 | 1890·1 | 2835·1 | 9 |
| 1 | 0·5541 | 2482·3 | 3723·5 | 8 |
| 1⅛ | 0·6969 | 3122·1 | 4681·1 | 7 |
| 1¼ | 0·8941 | 4005·5 | 6008·3 | 7 |
| 1⅜ | 1·0604 | 4750·5 | 7125·8 | 6 |
| 1½ | 1·3009 | 5828·0 | 8742·0 | 6 |
| 1⅝ | 1·472 | 6594·5 | 9891·8 | 5 |
| 1¾ | 1·753 | 7853·4 | 11777·1 | 5 |
| 1⅞ | 1·9855 | 8895·0 | 13342·5 | 4½ |
| 2 | 2·31 | 10348·8 | 15523·2 | 4½ |
| 2¼ | 2·9255 | 13106·2 | 19659·3 | 4 |
| 2½ | 3·7325 | 16721·6 | 25082·4 | 4 |
| 2¾ | 4·4637 | 20013·5 | 30020·2 | 3½ |
| 3 | 5·449 | 24411·5 | 36618·2 | 3½ |
| 3¼ | 6·4043 | 28691·2 | 43036·8 | 3¼ |
| 3½ | 7·5769 | 33944·5 | 50916·7 | 3¼ |
| 3¾ | 8·618 | 38608·7 | 57912·9 | 3 |
| 4 | 9·968 | 44656·6 | 66984·9 | 3 |
| 4¼ | 11·25 | 50400·0 | 75600·0 | 2⅞ |
| 4½ | 12·75 | 57120·0 | 85680·0 | 2⅞ |
| 4¾ | 14·18 | 63526·4 | 95289·6 | 2¾ |
| 5 | 15·9 | 71232·0 | 106848·0 | 2¾ |

The bolts must be of ample size and strength for the work required to be done, and as the shearing and tensile strength of wrought iron differs very little, the calculation will be the same as for the pump-rods.

The size of strapping-plates must be calculated in the following manner:—The weight to be lifted in tons, divided by two, equals the number of square inches area required in the plates; this again divided by the number of plates equals the sectional area in square inches of each plate; allowance must be made for the area of the bolt-holes.

### TABLE III.

SIZES OF STRAPPING-PLATES.

| Spears. | Strapping-plates and Bolts. | | | | |
|---|---|---|---|---|---|
| | Length. | Breadth. | Thickness in middle. | Thickness at ends. | Diameter of Bolts. |
| Sqr. inches. | Feet. | Inches. | Inch. | Inch. | Inch. |
| 3 | 6 | 2½ | ⅜ | 3/16 | ⅝ |
| 3½ | 6½ | 2¾ | ⅜ | 3/16 | ⅝ |
| 4 | 7 | 3 | ½ | ¼ | ¾ |
| 4½ | 7½ | 3½ | ½ | ¼ | ¾ |
| 5 | 8 | 3¾ | ⅝ | ⅜ | ⅞ |
| 5½ | 8½ | 4 | ¾ | ½ | ⅞ |
| 6 | 9 | 4 | ¾ | ½ | ⅞ |
| 6½ | 9½ | 4½ | ⅞ | ⅝ | 1 |
| 7 | 10 | 4½ | ⅞ | ⅝ | 1⅛ |
| 7½ | 10½ | 4¾ | 1 | ¾ | 1¼ |

There must not be any movement in the joints; therefore the utmost care must be exercised in making them. The holes in the plates and spears should be punched or drilled in such a manner as to allow for a little draw, to ensure of the joint closing perfectly.

Wood-spears should be made of perfectly sound Memel timber, free from defects and knots, and of the greatest length procurable; the lengths vary from 30 to 45 feet, but, whatever the length may be, all the rods should be exactly of the same length, so that a spare rod will fit any place. The safe load for the rods is 5 cwts. per square inch, but as the weight required on the spears for plunger-sets usually is very great, a much larger margin is given.

The top rods, joining the beam of Cornish engines, are usually fitted with top brasses only, the bottom half of the gudgeon working against the end of the wood-spear.

## TABLE IV.

### SIZES OF Y-PIECES OR U-PLATES.

| Spear. | Y-pieces or U-pieces. | | | | |
|---|---|---|---|---|---|
| | Length. | Breadth. | Thickness at U. | Thickness at ends. | Diameter of Bolts. |
| Sqr. inches. | Feet. | Inches. | Inch. | Inch. | Inch. |
| 3 | 4½ | 2½ | ⅜ | 3/16 | ⅝ |
| 3½ | 4¾ | 2¾ | ⅜ | 3/16 | ⅝ |
| 4 | 5 | 3 | ½ | ¼ | ¾ |
| 4½ | 5¼ | 3½ | ½ | ¼ | ¾ |
| 5 | 5½ | 3¾ | ⅝ | ⅜ | ⅞ |
| 5½ | 6 | 4 | ¾ | ½ | ⅞ |
| 6 | 6½ | 4 | ¾ | ½ | ⅞ |
| 6½ | 7 | 4½ | ⅞ | ⅝ | 1 |
| 7 | 7½ | 4½ | ⅞ | ⅝ | 1⅛ |
| 7½ | 8 | 4¾ | 1 | ¾ | 1¼ |

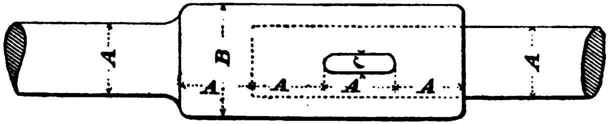
The solid iron rods should be made of the very best rolled, long-grained wrought iron; they should be well-guided by wood blocks or by roller guides. These guides will be fully described and illustrated under the proper head.

The tube rods are usually lap-welded, and should be of the very best quality.

## TABLE V.

### PROPORTION OF SOCKET JOINTS.

FIG. 146**.



| A | B | C | A | B | C | A | B | C |
|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| 5/8 | 1 1/8 | 5/32 | 1 1/2 | 2 3/8 | 3/8 | 2 3/8 | 3 3/4 | 19/32 |
| 3/4 | 1 1/4 | 3/16 | 1 5/8 | 2 1/2 | 13/32 | 2 1/2 | 3 7/8 | 5/8 |
| 7/8 | 1 3/8 | 7/32 | 1 3/4 | 2 3/4 | 7/16 | 2 5/8 | 4 | 21/32 |
| 1 | 1 5/8 | 1/4 | 1 7/8 | 3 | 15/32 | 2 3/4 | 4 1/4 | 11/16 |
| 1 1/8 | 1 3/4 | 9/32 | 2 | 3 1/8 | 1/2 | 2 7/8 | 4 1/2 | 23/32 |
| 1 1/4 | 2 | 5/16 | 2 1/8 | 3 1/4 | 17/32 | 3 | 4 3/4 | 3/4 |
| 1 3/8 | 2 1/8 | 11/32 | 2 1/4 | 3 1/2 | 9/16 | .. | .. | .. |

When the pump rods are used for raising water contaminated with some kinds of chemical matter, they should be made of gun-metal, Müntz-metal, or phosphor-bronze; but if they are of a large size, it is cheaper and quite as good to cover them with the metal required; this can be done by forcing a tube on them, or they can have a tube drawn on them by tube makers, the rod itself being used as the mandril in the machine.

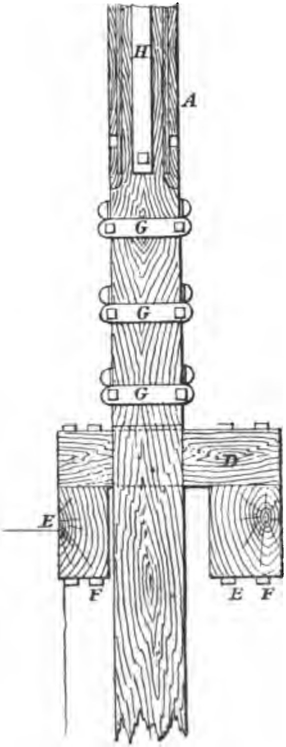
## SPEAR-ROD-GUIDES, ETC.

### Banging Beams and Catches or Wing at Top of Pit.

The use of the catches and banging beams is to prevent the engine from working too long stroke, and to obviate the breaking of the engine in case of an accident to the main-spears, bursting of a pipe in the shaft, or the pump failing to fetch its water, hence preventing injury to the remainder of the machinery and pit work.

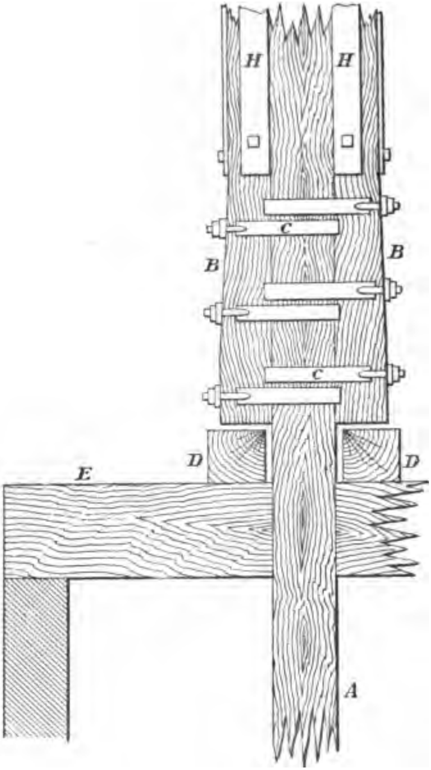
The illustration, Fig. 147, shows the banging beams and catches at the pit top for a set of 16-inches wood-top spear, A, which has fitted to it two wings or catches, B B, Fig. 148, consisting of strong, sound beams of timber, by means of three strong wrought-iron staples, C, and glands, G, to each catch; D D are two banging beams, resting on two bearers, E E, carried across the pit mouth, and secured to the same by four bolts, F F. Of course, the depth and number of the beams are determined by the size of

Fig. 147.



engine and weight of spears, plungers, set-offs, etc.—in fact, all the weight the engine has to lift at each stroke; ofttimes there are as many as six beams, E, resting one on the top of the other. These catches may be secured to the spears either as in the illustration, to prevent the engine going too far on the out-door stroke, or when they have to prevent the engine from working

FIG. 148.



too far in the in-door stroke, the wings are secured under the banging beam. The in-door catches should be placed as near the top of the shaft as possible.

## Top Spear Guide.

The top spear guide in a pit shaft is illustrated in front

Fig. 149.

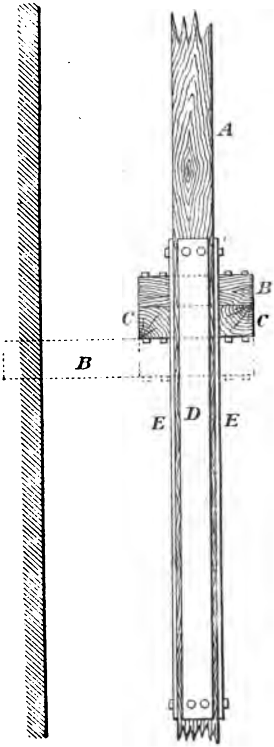
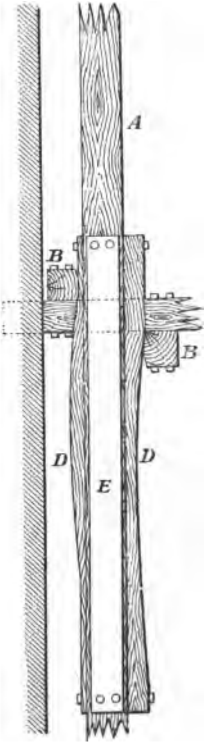


Fig. 150.



elevation, Fig. 149, and side elevation, Fig. 150. A is the spear rod, having the curved piece of timber, D D, bolted to it. These pieces are cut to a radius proportioned to that of the radius of main gudgeon to centre at the spear gudgeon on the engine beam, the concave part being on that side of the spear farthest from the engine; these curved pieces work between two cross-pieces, B B, the upper one being bolted to the top of the two beams, C C, secured across the pit shaft, and the bottom one bolted up to the beams, C C, also secured at one end to the side of the pit shaft. The two beams, B B, are slightly rounded on the inside, so that the guide pieces, D D, will work smoothly against them. E E are two pieces of hard wood, such as oak, birch, or elm, bolted to the sides of the spears, A, to prevent the spears from wearing by friction; these pieces are technically termed wearing plates; they are usually made from 1 inch to 1¼ inch thick, and are constantly kept well greased. Some engineers prefer wrought iron for wearing plates, instead of wood strips; there is this objection to them, that they wear the guide beams, B B, faster than when made of wood correctly; if wrought-iron plates are used, the guide beams should also be faced on the curved side with wrought-iron strips, and kept well lubricated.

## BANGING BEAMS AND CATCHES IN PIT SHAFTS.

The catches in the pit shaft, like those at the top of the shaft, are generally made of wood, but sometimes cast iron is employed for their construction, as illustrated in Figs. 151 and 152. A is the spear, B B are the wings or catches made of cast iron, securely bolted to the spears, A, by the two rows of bolts, C C. These bolts are placed in such a manner that they just clear the sides of the spears, as shown in front elevation, Fig. 152, and *not* to pass through them, for by that means the whole strength of the spears is obtained. D D are the two banging beams,

Fig. 151.

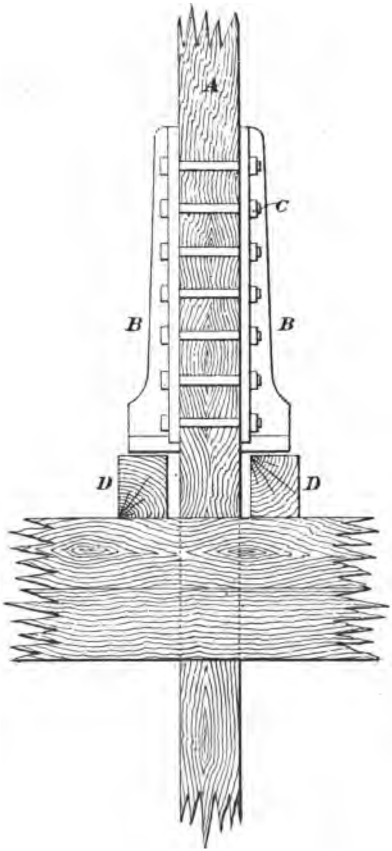
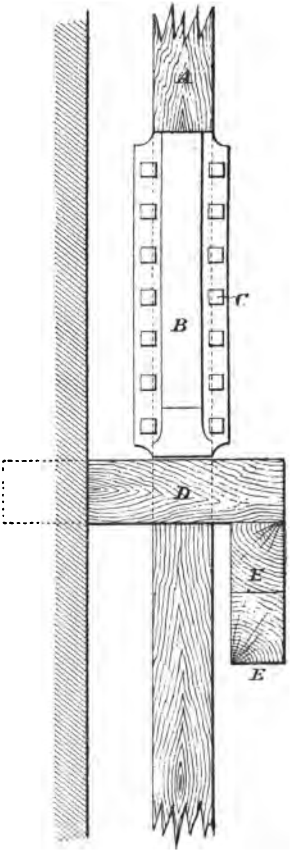


Fig. 152.



one end of which is carried in the side of the shaft, the other end being secured to two beams, E E, carried across and the ends built into the shaft. There are usually one set of these catches and banging beams arranged for each length of the spears in the shaft.

The vibration of the spears is prevented by guides; these guides, when made of wood, consist of pieces of timber securely fastened to the sides of the shaft. Sometimes two timbers only are used side by side, leaving a

FIG. 153.

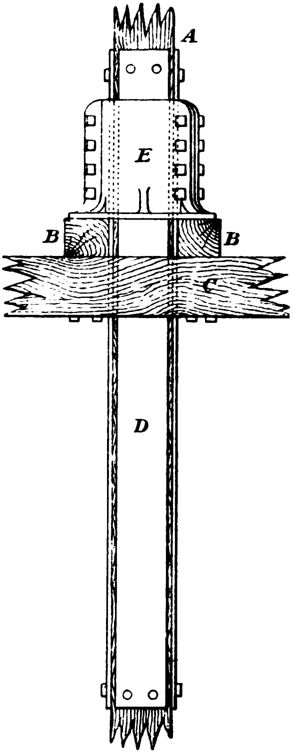
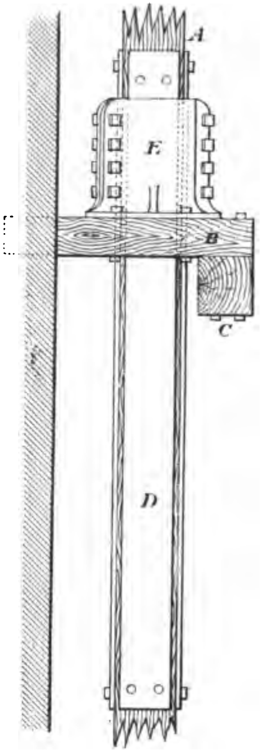


FIG. 154.

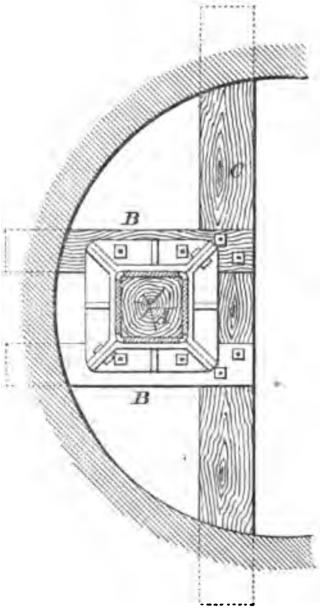


small clearance between them and the spears. When this is the case, the pairs should be placed at right angles to the one above it, so that the first pair prevent the vibration one way, and the next pair the other way. We advise the first pair being placed on the sides nearest and farthest from the engine, the next pair below at right angle to those above. These guides also keep the rods in a straight line.

The better plan for wood guides is to secure two beams in the shaft with two cross beams bolted down on the top side, the four pieces making a square hole or guide for the spears to pass through.

Cast-iron wood-spear guides are sometimes used; these are illustrated in side elevation, Fig. 153; front elevation, Fig. 154, and plan, Fig. 155. In these figures, A A is the wood-spear, faced with hard wood wearing plates or pieces, D D; E E is the cast-iron guide, made in halves, bolted together at cross corners, allowing them to be readily removed when necessary. The guide castings are provided at the bottom with a strong, well-ribbed flange, securely bolted to the wood-beams, B B, which have one end fixed in the side of the shaft, the other end being bolted down to a cross-beam, C, each end of which is built

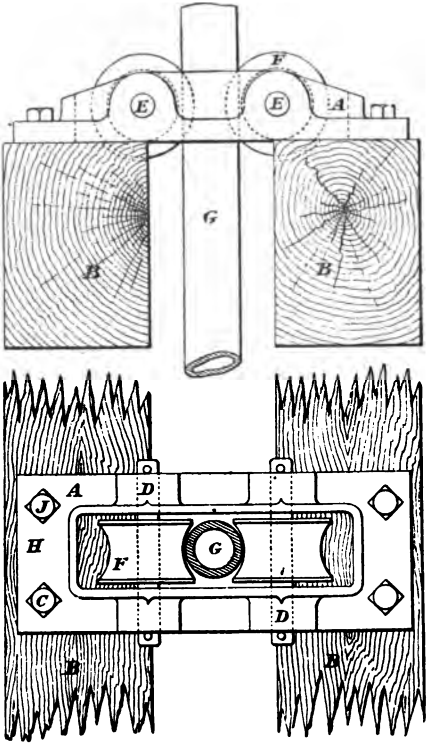
FIG. 155.



into the sides of the shaft. These three beams are clearly shown in the plan, Fig. 155.

Guides for round rods are made either of wood, cast iron, or wrought iron. The wood guides consist simply of a piece of timber, into which a half-round groove, of a little larger radius than the rod, is cut perpendicularly, the ends of the beams being secured to the sides of the

Figs. 156, 157.



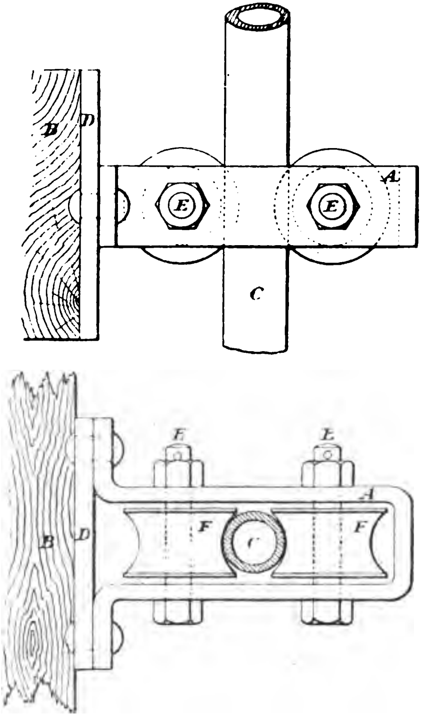
shaft. Another shorter piece of timber, say about 2 feet long, for a single-barrel pump, having a corresponding half-round groove cut into it, is bolted to the beam in such a position that the two half-round grooves form a circular hole for the rod to work through. This forms a very simple guide, although it causes a great deal more friction than the roller guide.

For three-throw pumps the guide is often made in the same way, but there are in those cases three holes instead of one.

In some cases the guide is made as just described, except the hole is made larger, that the rod works perfectly clear through it, a cast-iron boss being bolted to the top of the timbers, furnished with a chamber at its upper end, in which a constant supply of grease is kept, to reduce friction.

The best guides are the roller type, because the friction in them is reduced to a minimum. One of these is illustrated in elevation, Fig. 156, and plan, Fig. 157. It consists of a cast-iron frame, A, resting on two wood beams, B B, secured in the sides of the well or shaft, the frame being held firm to the beams by means of the four coach screws C C C and J. The frame is furnished with four bosses, D D, two on each side; these bosses are bored out to receive two pins, E E, fitted with two rollers, F F, usually from 3 to 6 inches diameter, the tube or solid wrought iron or steel rod, G, passing between the two rollers, forming an excellent guide, the friction being very small indeed. In some cases one of the ends, say at H, is open, a wrought-iron clip being fastened down by the coach-screw C, and in that case J is a bolt passing through the wood beam B, instead of a coach-screw, the object being that the whole frame, A, can be removed, when desired, without uncoupling the rod G. The rods in this example consists of 2-inch tubes, $2\frac{7}{8}$ inches external diameter, the rollers being $3\frac{1}{2}$ inches diameter at bottom of groove. The pins, E E, are plain rods, furnished with an ordinary split pin at each end.

Figs. 158, 159.



A set of roller guides, slightly different in arrangement from the previous one, is illustrated in elevation, Fig. 158, and plan, Fig. 159. It will be seen that it is identical in style, but the frame, A, is of wrought iron, bolted up to one wood beam, B, instead of on the top of two wooden beams. D is a wrought-iron plate, riveted to the frame, A, and bolted to the beam B. The rod, C, is 2 inches external diameter; the rollers, F F, 2½ inches diameter at the bottom of the groove. The spindles, E E, in this case are ⅞-inch diameter, consisting of plain turned bolts with split pins provided outside the nuts to prevent them getting loose by the constant vibration.

Figs. 160 and 161 illustrate a half elevation and half section, and plan respectively, of a set of roller-guides for three-throw pumps. A cast-iron girder, A, is provided with a flange on one side, the ends being secured in the sides of the well. The flange has six holes drilled in it for the roller pins, E E, and four holes for the distance bolts, H H. A wrought-iron plate, B, having holes corresponding to those in the flange, is bolted up to the girder by the bolts, H H, and distance-pieces, J J, securing the six rollers, F F, and pins, E E. The pins in the best class of work are made of steel. It will be seen from the illustration that this girder is also used for the purpose of staying the rising-main or delivery-pipe. These pipe-stays will be described fully under the proper head, "Pipes, pipe-joints, and pipe-stays." G G are solid wrought-iron well-rods or spears.

The square wood spears are sometimes guided by rollers. These rollers are usually made of hard wood, four in number, each fitted into a small cast-iron bracket, and all four secured to a wood frame, fastened to the sides of the shaft.

The wet spears, that is, pump-rods, which work inside the pump-trees of a bucket-lift, when of wrought iron, are sometimes guided by means of pieces of wood fastened together with bolts, firmly gripping the rods. These pieces of wood are made a little shorter than the internal diameter of the pump-trees, and placed at right angles to

FIG. 160.

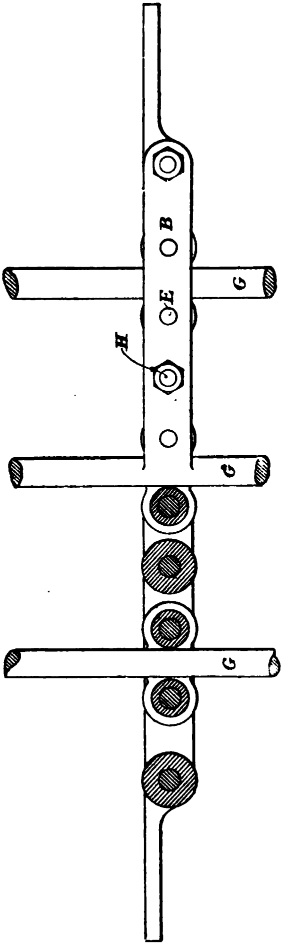
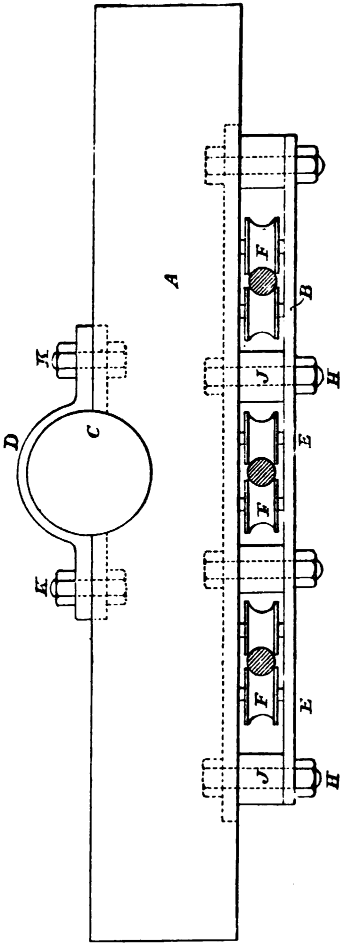


FIG. 161.



one another, in such a manner that one set guides the rod in one direction, and the set below it in the opposite direction. These guides are usually placed one in every alternate length of pipe, that is, about 18 feet apart on the rod.

## REMARKS ON DESIGNING BANGING BEAMS, CATCHES, SPEAR AND ROD GUIDES.

All the timber must be of the very best quality of memel, free from defects of any kind. In cases where the spears are very long and heavy, they must be made taper, being reduced in size below every pump in the shaft, or else the weight of the spear, in many cases, will be so great that they cannot carry their own weight. The wrought iron should be of the best make, such as Low Moor or Farnley. Cast-iron catches or wings are only used when the lift is low and the plunger large, for then the weight requires to be increased.

All the beams in connection with the banging beams and guides should be firmly secured to the well or shaft sides. In that part of the shaft which is brick work this is an easy matter, as it is also to secure it into the part which consists of solid rock, by means of wedges firmly driven in, and afterwards well made up with neat cement. When the beams come at that part of the shaft which is tubbed with cast iron, they should be secured with strong well-bracketed sockets, bolted to the cast-iron tubbing.

The curve of the guide-pieces, D, Fig. 150, should be carefully cut to the proper radius, as already referred to, and the guide beams put in exact position, otherwise there will be a great strain on the spears and guide beams.

In heavy pit work the guides for wood spears are usually fitted one for each length of spear; for solid wrought-iron rods, used with bucket-lifts, the distance between the guides varies from 15 to 20 feet, but for wrought-iron rods, used for plunger-pumps, or force-pumps, the distance of 9 to 10 feet should not be exceeded.

Roller guide-frames are sometimes made of cast iron, as shown in Figs. 156 and 157, at other times of wrought-iron, as in Figs. 158 and 159. In all first-class work, the rollers are bushed with gun-metal, turned on their faces with a tool corresponding to the shape the groove should have, to ensure them running easy and perfectly true, and the exact diameter, so that very little clearance need be given between the rods, solid or tubes, and the rollers. The less clearance the better for steady working. The guides should be placed at such positions that they clear the rod joints when working.

Sometimes the pipe clips, for steadying the rising main or delivery pipe, are secured to the same beams as the rod-guides, at other times they are made part and parcel with the roller-guide girder, as in Figs. 160 and 161. These clips will be fully described under the head of "Pipes, pipe joints, and pipe stays."

# VALVE SWORDS, SPINDLES, AND DRAW-HOOPS.

## Valve Swords.

The valve swords are used for butterfly valves, securing the valve to its seat across the centre line. One of these is illustrated in Figs. 162 and 163. It will be seen from the illustration that it is in every way similar to the bucket-sword, Figs. 106 and 107, except that instead of the knock-off joint, A, it is furnished with a hook, G. F is the flat sword, formed with a shoulder, C, resting upon the valve leathers on the top of the valve sheet or shell, the sword passing through a boss formed in the centre of the seat; underneath the shell is driven a cotter, E, prevented from working out by means of a split pin, H, D being a cross-bar placed between the boss in the shell and cotter, E. The use of the hook, C, is to withdraw the clack and seat in case the clack-piece door should be under water, and the clack out of order. The appliances for withdrawing it will be fully illustrated and described under the head of "Fishes and Drawhooks."

## Valve Spindles.

A plain spindle, for a valve with a perpendicular lift, is shown in Fig. 164. It consists of a spindle, E, having its bottom end, F, reduced so as to form a shoulder against the valve seat, and secured to it by a nut, N. The top part of the spindle, at O, is screwed, and the extreme top end, P, turned to a cone; this arrangement is for withdrawing the valve and seat.

A slightly modified arrangement of a centre spindle is illustrated in Fig. 90, in which the top of the spindle is furnished with a ring, E, instead of the screwed part, O, the bottom part being secured by a nut and cotter behind it.

Fig. 162.

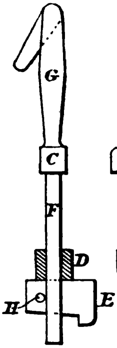


Fig. 163.

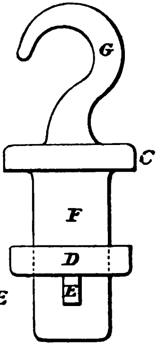
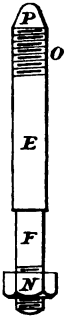


Fig. 164.



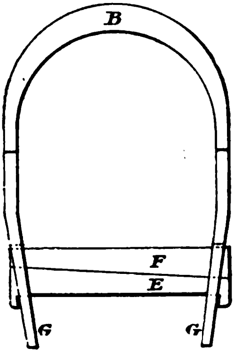


Fig. 165.

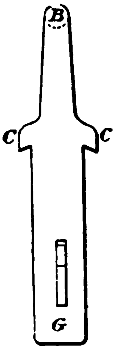


Fig. 166.

## DRAW-HOOP.

A draw-hoop or bow for a drop-clack is shown in Figs. 165 and 166. The purpose of this hoop is to lower the drop-clack, and to raise or withdraw it again when not wanted. It is like the bucket-fork or prong, Figs. 103 and 104, but it has no knock-off joint, A; it consists simply of a hoop which is round at B, and gradually flattened down to the two fork ends, G G, and the half-moon, Fig. 105, is dispensed with, it only being fitted with the gib, E, and cotter, F, because, in this case, there is no bucket-hoop to hold fast.

## SET-OFFS OR OFF-SETS.

Set-off is the usual technical term for the distance-piece secured between the main-spears and the plunger-pole, and the main-spear and bucket-rods. They are made either of wood, wrought iron, or cast iron.

Figs. 167, 168, and 169 illustrate the most common method adopted for uniting the ordinary plunger-pole and the main-wood spears. B is the plunger-pole, A the main-rod, C the set-off, D D are staples made of plat-iron bars, forged round, and screwed at each end; E E are the glands or cross-bars, shown in plan, Fig. 169, against which the nuts, F F, are tightened. The plunger-rod, B, is sometimes made longer, reaching above the set-off, C, and guided by means of four pieces of timber. The main-spears in this example are 18 inches square, the plunger-pole 13 inches square, the set-off 9 inches thick, the staples are 4 inches wide by 1¼ inch thick, and the screwed part at the ends 2 inches diameter.

Sometimes in Cornwall a short spear, G, is secured to the main-spear by an ordinary set-off, and the spear, G, again secured to the bucket-spear, B, in this case a wrought-iron plate furnished with a hook, H, the plate having a heel, J, let into the wood-spear, G, and fixed firmly by the staples, D, glands, E, and nuts, F; another plate with a hook, K, is fastened to the bucket-spear, B, with similar staples, glands, and nuts; these two plates are joined together by the link, L. The bucket-rod, B, and short spear, G, are, besides, held firmly together at the top of B by another staple, gland, and nuts, marked M. This arrangement is shown in side elevation, Fig. 170.

A wrought-iron set-off is illustrated in side elevation, Fig. 171, and front elevation, Fig. 172. A is a flat wrought-iron plate, to the middle of which is forged a pin, B; on this pin works the solid wrought-iron bucket-rod, F, which in this example is 2½ inches diameter, being

FIG. 167.

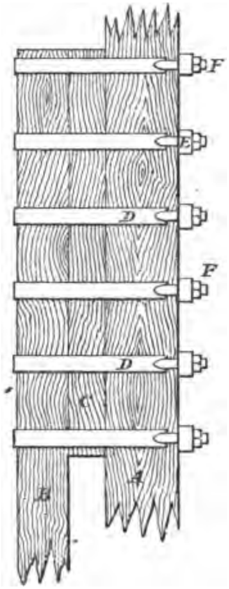


FIG. 171.

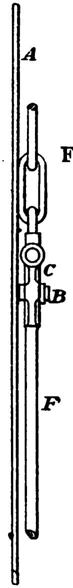


FIG. 170.

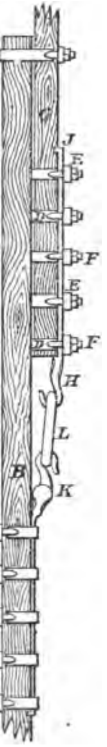


FIG. 172.

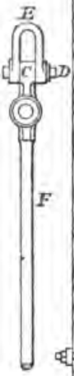


FIG. 168.

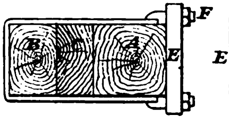


FIG. 169.

prevented from coming off by a washer and split-pin; F is the bucket-rod, on the top end of which is forged an eye, C, to which latter a shackle, E, is secured by a pin, D, washer and split-pin, the shackle passing through an enlarged link at the end of a chain. The object of this plan is that when the bucket-lift is employed for sinking, instead of having the trouble and delay of unfastening all the staples, glands, and nuts, and lengthening the spears every time the working-barrel is lowered, the rod, F, is removed from the pin,. B, and any link in the chain is secured to the pin, so as to lower the bucket the required depth in the working-barrel. In such cases the barrel is made much longer than is necessary for the depth of the bucket and real length of the stroke. Frequently a hook is used instead of the pin, B, which hook is undoubtedly more appropriate for a chain to be fastened to than the pin. It should be borne in mind that the chain should never be allowed to work into the pump-trees, because in case of the chain breaking, it would be more difficult to fish out than a rod. In this example the plate was 12 feet long by 8 inches wide, by 1½ inch thick in the middle, tapering towards each end to ⅞ inch. The pin, B, was 3 inches diameter, and the boss on the rod 3½ inches long; the shackle 2 inches diameter, chain 1½ inch diameter. The plate was secured to the wood-spears by eight bolts, each 1½ inch diameter.

Another example of a wrought-iron set-off for a bucket-lift is illustrated in Figs. 173 and 174, Fig. 173 being a side elevation and Fig. 174 a front view. This arrangement was used in a case where the plunger-set was small, the centre of the plunger-set and bucket-lift being very little; the plunger and bucket were both 6 inches diameter, with a stroke of 4 feet; the wood-spears were 5 inches square, and the bucket-rod 2 inches diameter. The plate, B, was 2 feet long by 5 inches wide, $\frac{5}{8}$ inch thick; the heels, E E, let into the timber $\frac{3}{4}$ inch deep. The pin, D, $2\frac{1}{2}$ inches diameter, was furnished at the end with a washer and split-pin. The wood part of the set-off, C, was $2\frac{3}{8}$ inches thick by 5 inches wide. The staples, F F, were 2 inches wide by $\frac{5}{8}$ inch

FIG. 173.

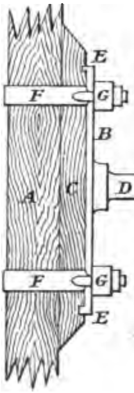


FIG. 174.

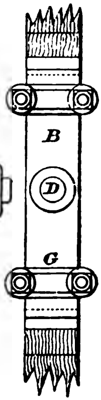
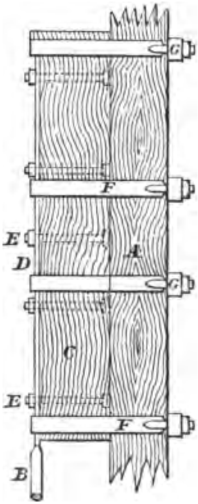


FIG. 177.



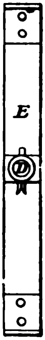


FIG. 175.

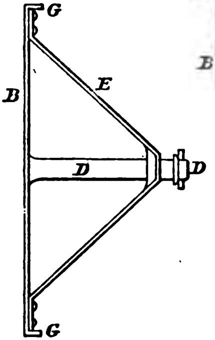


FIG. 176.

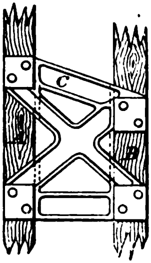


FIG. 178.

thick in the flat part, and the two ends screwed ¾ inch diameter; the glands, G G, were made of 2 inches by ⅝ inch flat iron—the staples in this case were only two in number, one above and one below the pin, D. A is the main-spear.

In the previous set-offs part of the distance between the centre line of the two pumps was made up by the wood set-off, C, but in the example which is illustrated in Figs. 175 and 176, the whole distance is made up by wrought iron. This set-off was made for a 12 inches bucket-lift for a 45 yards lift. It consists of a wrought-iron plate, B, 5 feet long by 6 inches wide, by 1¼ inch thick, secured to the main wood-spears by ordinary wrought-iron staples, glands, and nuts; D is the pin, 3 inches diameter, to which the bucket-rod is attached; E is a wrought-iron stay ¾ inch thick by 6 inches wide, furnished with a boss, F, which acts as a stay for the pin, D, this pin being 3⅛ inches rough forging between the plate and boss on the stay, the rest of the pin being turned to fit the hole in the boss, F, and the bored hole in the top part of the bucket-rod, the latter being 2½ inches diameter. Each end of the stay, E, is securely riveted to the plate, B, which latter, as additional security, is turned up at the ends marked G G. The bucket-rod is prevented from slipping off the pin, D, by a washer and split-pin.

Next we come to a set-off frequently used. It is illustrated in Fig. 177, and consists of a spear, A; wood-set-off, C; bucket-rod, B, the latter being made of solid wrought iron, flattened out at the top end, D. The rod is secured to the set-off, C, by five bolts, E, passing through both, and the set-off, C, is secured to the main wood-rod, A, by means of four staples, F F, four glands, G G, and nuts.

Cast-iron set-offs are seldom used. One of these is illustrated in elevation, Fig. 178, consisting of two castings, C, one on each side of the main-spear, A, and plunger-pole, B. These two castings are secured to the spears and poles by means of bolts passing through them, and are also held rigid by lips on the inside of the set-off; by them the distance is always kept the same between the rods, and the bolts are relieved from any twisting strain.

# PIPES, PIPE-JOINTS, AND PIPE-STAYS.

## PIPES.

A very important matter relating to pumps, and one requiring careful consideration, is the pipes, both with regard to the size and thickness and the manner in which they are joined together.

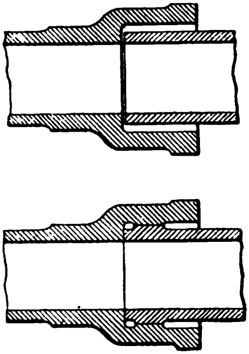
The diameter and thickness of the pipe is of course determined by the quantity of water to be raised in a given time, and the height it has to be forced or lifted to. The pump-trees for a bucket-lift should be 1 inch larger in diameter than the working-barrel, so that the bucket can pass easily down them. In other pumps the size of pipe should be so calculated that the speed of the water through them does not exceed 200 to 250 feet per minute, the former speed being preferable.

Two kinds of pipes are used, namely, "spigot and socket," and "flange pipes."

## SPIGOT AND SOCKET PIPES.

These pipes are hardly ever used in mines and collieries, on account of the difficulty of separating the joints after they have once been made; but they are of a great convenience when laid horizontally, having the advantage that, when there is play in the socket and lead run into them, they allow a departure from a straight line. When the spigots are turned and the sockets are bored to fit one another, as some engineers prefer, no deviation from the straight line can be made. Another advantage with these pipes is that no exact making-up lengths are required, as the spigot end of the pipe can be easily chipped or turned off to any length required, and by that means very little time is lost, in comparison to having a special flange-pipe cast, which in many instances means two or three days' delay.

Figs. 179, 180.



The usual not turned or bored socket-pipe is illustrated in Fig. 179, and the turned and bored socket-pipe is shown in Fig. 180.

## Flange Pipes.

Flange pipes are mostly used for pump work, particularly for water.

The most common pipe joint is illustrated in Fig. 181. It consists of a lead or wrought-iron ring, the former being preferable on account of the iron corroding, wrapped round with flannel or common woollen cloth, soaked in Stockholm tar. When iron rings are used, they are generally turned $\frac{1}{8}$ inch thick. When lead rings are used, the ends of the pipes do not require facing on account of the soft nature of the lead, although in all first-class work the pipe flanges are faced.

A very cheap and efficient joint, illustrated in Fig. 182, consists of an india-rubber ring placed between the two flanges. It is not imperative that the flanges should be faced, but they generally are, because it makes it easier to get all the pump-trees in a straight line.

A flange pipe joint, with spigot and faucet, is illustrated in Fig. 183. The joint in this case is made in the same manner as the two previously described joints, the object of the spigot being simply to keep the ring in position till the joint is made, hence it is not necessary to make the spigot long.

Fig. 181.

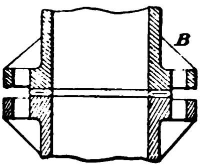


Fig. 184.

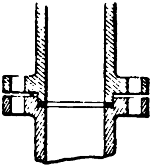


Fig. 182.

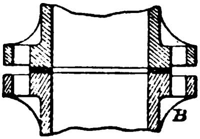
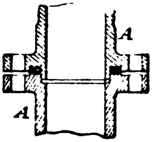


Fig. 185.



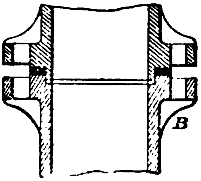


Fig. 183.

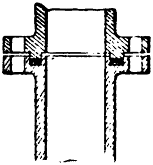


Fig. 186.

Flange pipes, with spigot end faced, are sometimes made as illustrated in Fig. 184. This differs from the previous joint only in that the joint ring is placed at the bottom of the faucet. The ring is sometimes made of india-rubber; at other times it consists of a lead ring carefully wrapped round with lamp cotton, without any tar or oil.

At other times a groove is turned in the flange having a spigot, an india-rubber ring being put into it, as illustrated in Fig. 185.

Again, a groove may be turned in one flange, and a projecting ring, corresponding to the groove, on the other, an india-rubber ring being placed in the groove; this plan is shown in Fig. 186.

For heavy pressures, pipe joints are made in the manner illustrated in Fig. 187. The joint consists of a spigot turned to fit a faucet, the latter being bored out and chamfered at the top; a gutta-percha cord, which is made into a ring by cutting the ends of the cord at an angle, dipping them in hot water, then pressing them together by the fingers placed round the spigot. This joint is excellent for pressures up to about 600 to 700 lbs. pressure per square inch.

FIG. 187.

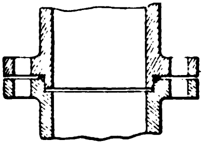
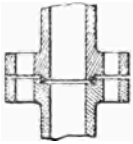


FIG. 189.



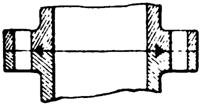


FIG. 188.

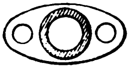


FIG. 190.

Fig. 188 illustrates another very simple gutta-percha joint. As will be seen from the illustration, it consists of two ordinary flanges faced straight across, and having a ring cut with a diamond tool in each flange, with the inside of the groove straight, so that when the two flanges are put together the two grooves form a triangular groove. A round gutta-percha cord, made into a ring in the manner previously described, is put into the groove before the flanges are bolted together. It will be noticed that when pressure is introduced into the pipe it will act on the flat surface of the triangle, and try to force the gutta-percha into the joint, and by that means form a perfectly tight joint; the greater the pressure the better the joint.

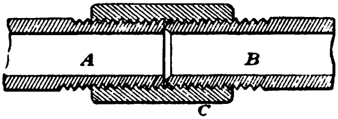
The last illustration of a joint for cast-iron pipes is Figs. 189 and 190, and was originally introduced by Lord William Armstrong for his hydraulic machinery. In this case both the spigot and faucet are turned at an angle of 22½ degrees, so that the triangular space formed by them has an angle of 45 degrees, and a gutta-percha ring is placed at the bottom of the faucet. For cast-iron pipes the width of the faucet all round the bore of the pipe is ⅜ inch, and ⅜ inch is the greatest depth of the spigot. For a 3-inch pipe the recess is 3¾ inches diameter. For wrought-iron pipes the diameter of the recess should be equal to the outside diameter of the pipe, and the greatest depth ⅜ inch; the gutta-percha cord being in all cases ¼ inch diameter. The outside diameter of hydraulic wrought-iron pipes is equal to the outside diameter of the next larger size of gas pipe. A 1-inch pipe equals outside diameter of 1¼ inch gas pipe equal to 1$\frac{9}{16}$ inch diameter.

## WROUGHT-IRON PIPES.

The joints for wrought-iron pipes or tubes are either made flanged, the flanges being screwed on, or with socket, as usual for gas or ordinary water pipes.

A very good method to ensure a good joint on wrought-iron pipes of small diameter, for heavy hydraulic pressures, is shown in Fig. 191, in which A is one length of piping, B another length coupled up to it, and C is a right and left-hand coupling. It will be seen that the pipe A is faced perfectly flat and the end of B turned to a knife-edge, which edge, when the pipes are drawn together, form a good, sound joint against the flat end of the pipe A.

FIG. 191.



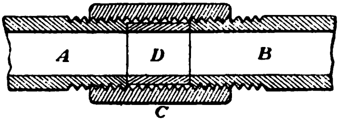


FIG. 192.

Another plan, illustrated in Fig. 192, consists of the ordinary right and left-hand screw coupling C, and a short piece of tube or ferrule D introduced between the ends of the pipes A and B; this ferrule is made of an alloy possessing the property of being tough and at the same time comparatively soft and expansive. In addition to making the joint, at the screwed part, one is also made by the two ends of pipe butting against the ferrule. If the pipe should happen to be screwed too small to make a good joint in the usual way, the addition of the ferrule enables one to be made with certainty, and with the extra advantage of obtaining a uniform internal diameter for the piping.

The American wrought-iron oil line pipes for petroleum are lap-welded, and in lengths of 18 feet; they are fitted at each end with coarse and sharp cut taper threads, 9 to 1 inch, and with long sleeve couplings, also screwed taper. The taper is usually ¾ inch to the foot for 4-inch pipes.

Wrought-iron pipes and pump-trees have now become almost a standard practice. Their lightness, as compared with cast-iron pipes, is a great recommendation; the freight and cost of transportation in mountainous districts, as in Mexico, being thereby greatly reduced. It is, at first sight, difficult to understand how wrought-iron and steel pipes can compete in price with cast-iron; the reason is obvious when we consider that on an average the weight required, as compared with cast-iron, is only one-fourth to one-fifth, and is constructed with only one-third the number of joints, when placed in position; this latter being a great consideration, especially in long lengths of pipes.

Although wrought-iron pipes have been made and used in America for upwards of thirty years, Messrs. Thomas Piggott & Co., of Birmingham, have been without a doubt the pioneers in the wrought-iron and mild-steel pipe trade in England.

One great objection to the steel pipes is that, if exposed to the weather, corrosion is certain to take place more quickly than in cast-iron, but this objection is perfectly overcome by being coated with a good coat of anti-corrosive composition. A proof of this is, that some pipe lines in America have now been in daily use over thirty years, and are as good as the day they were laid down.

Wrought-iron pipes are made in various methods. Small pipes are either solid-drawn or welded. An American firm made the pipes with spiral riveted seams, and the most recent American method is to make them of steel with a spiral welded seam; pipes of the latter type have been made 57 feet long by 10 inches diameter.

The spirally-made pipes, with riveted seams, are the most rigid, and are, therefore, to be preferred when rigidity is required.

The welded wrought-iron and steel pipes are made from 8 inches diameter upwards to any diameter, but to make the pipe of one plate the size is limited by the size of plate procurable. Approximately, for welded pipes, $\frac{1}{4}$ inch thick by 26 inches diameter is the largest for which a plate can be obtained; for pipes thicker than $\frac{1}{4}$ inch, plates can be had for pipes about 28 inches diameter. Riveted pipes, built up of plates about 4 feet wide, can be made of any diameter.

Welded pipes can now be made up to 17 feet 6 inches long, and a very usual length for riveted pipes is 24 feet.

Riveted pipes are tested up to a pressure of 200 lbs. per square inch, as that is about the greatest pressure that a double-riveted joint will keep tight. Welded pipes are tested to a much higher pressure. Eight inches to 18 inches diameter pipes, $\frac{1}{4}$ inch thick, are tested up to as much as 400 lbs. per square inch, although the usual test pressure for ordinary sized pipes, about $\frac{1}{4}$ inch thick, is 250 lbs. per square inch.

The method of joining wrought-iron or steel pipes, of large sizes, consists in furnishing both ends of the pipes with flanges; with sockets on one end, the other plain; or with a double socket and both ends of the pipe plain.

The flanges for wrought-iron pipes are usually also of wrought iron, sometimes stamped out of steel plates; but for hydraulic work they are mostly made of cast iron. Flanges on small pipes are screwed on, and should be slightly riveted over; on large pipes the flanges are riveted to the pipe. Sometimes the flange is made of an L-iron ring, of 2 by 2 by $\frac{3}{8}$ inch, $2\frac{1}{2}$ by $2\frac{1}{2}$ by $\frac{3}{8}$, 3 by 3 by $\frac{1}{2}$, and $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{5}{8}$ inch L-iron, according to the diameter and thickness of the plates of which the pipe is made; these L-iron rings being riveted to the ends of the pipe, as illustrated at A and B, Fig. 193. The wrought-iron flanges are always faced straight across.

FIG. 193.

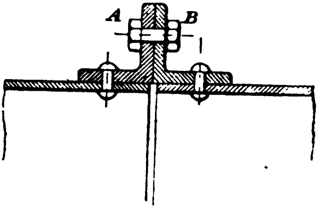


FIG. 194.

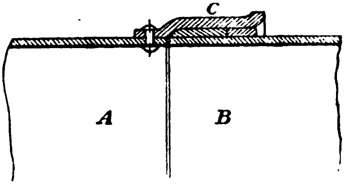
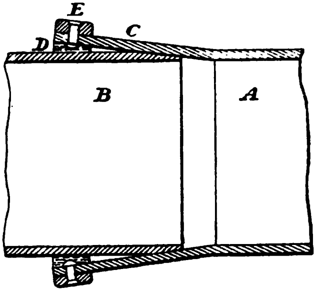


FIG. 195.



The common socket for wrought-iron pipes is illustrated in Fig. 194; A being the pipe to which the socket is secured, C the socket, B the pipe end forming the spigot.

It will be seen that these sockets are riveted to the end of the pipe. The joints are made in the usual manner, with spun yarn and lead.

Messrs. Piggott's patent socket is illustrated in Fig. 195. A is the socket end of one pipe, the socket C being made in one with the pipe, the rim of the socket being strengthened by a wrought-iron hoop, E, riveted to it; B is the spigot end of the next pipe, which is at the extremity chamfered off. Hemp is placed at the bottom of the socket, and D is the lead for making the joint.

Another type of pipe joint illustrated in Fig. 196 consists of two sockets, A, made into one, and the pipes have both ends plain. This appears a very simple joint, but it seems as if there would be considerable difficulty in laying the pipes correctly with these small collars; the difficulty of getting the two pipes and the collar all truly concentric must also be considerable; in caulking the lead at one side of the collar, or socket, there will be a great danger of disturbing and loosening the joint on the other side. These joints were made for the Kimberley Waterworks pipes, laid down in the year 1880, 14 inches and 18 inches in diameter.

Fig. 196.

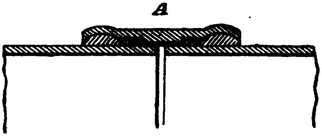
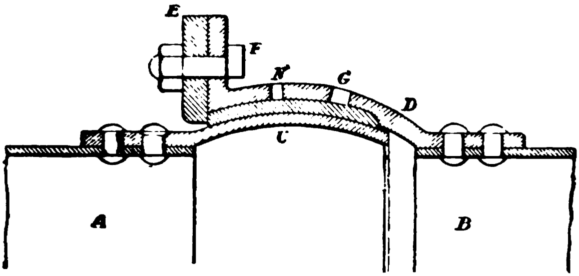


Fig. 197 is a section of a ball and socket joint, as used for the temporary steel line-pipe laid on the bed of the river Mersey for the Vynwy Water supply to Liverpool. A is the end of one pipe, B the end of the other; these pipes being 12 inches internal diameter by ¼ inch thick steel plates; C is the ball, and D the socket, each riveted securely to their respective pipes by two rows of rivets; E is a gland bolted to the socket, D, by means of fourteen steel bolts, F, 1¾ inch diameter. It will be seen that the end of the socket nearest the gland is a little larger in diameter than the largest diameter of the ball, C, the latter having a radius of 7⅜ inches. The two pipes were placed in position and lead run in through two holes, G, each ¾ inch diameter and 1 inch apart. H is a vent-hole ⅜ inch diameter. This makes an excellent ball and socket joint for large pipes.

FIG. 197.



## REMARKS ON DESIGNING PIPES.

In rising mains or pump-trees, the thickness should be calculated for every 200 feet head, reducing the weight as much as possible, on account of handling them in the pits, and the prime cost and carriage; but, of course, the first thing to be borne in mind is their efficiency.

The cast-iron pipes for mines, collieries and waterworks are invariably made in 9-feet lengths, with a few matching pieces or making-up lengths 6 feet and 3 feet long, to make up the different stages in the well or shaft.

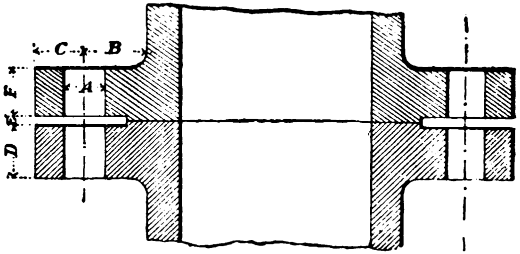
Some engineers and pit-men like belts or strengthening rings round the pipe, usually two on each 9 feet length, and one at the root of each flange, as illustrated at A A, Fig. 185. This method is very convenient for slinging the pipes when they are lowered down into the shaft, also for staying them when fixed, the stay being secured against them.

The ribs, B, between the bolt-holes in the flanges are made of various shapes. The design shown in Fig. 181 is not to be recommended, as they are invariably in the way of the spanner when the bolts are tightened up. Many engineers object to the rib, B, illustrated in Fig. 182, because it does not strengthen the flanges at the periphery of the same, so they use the rib, B, shown in Fig. 183, which is stronger at the periphery, and still leaves more room for the spanner than the rib, B, in Fig. 181.

## TABLE VI.

### PROPORTIONS OF ROUND CAST-IRON FLANGES.

FIG. 197*.



| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Inches. | Inches. | Inches. | Inches. | Inch. | Inches. |
| $\frac{1}{2}$ | 1 | $\frac{7}{8}$ | $\frac{3}{4}$ | $\frac{1}{4}$ | $\frac{3}{4}$ |
| $\frac{5}{8}$ | $1\frac{1}{8}$ | $\frac{7}{8}$ | $\frac{7}{8}$ | $\frac{1}{4}$ | $\frac{7}{8}$ |
| $\frac{3}{4}$ | $1\frac{1}{4}$ | 1 | 1 | $\frac{1}{4}$ | 1 |
| $\frac{7}{8}$ | $1\frac{3}{8}$ | $1\frac{1}{8}$ | $1\frac{1}{8}$ | $\frac{1}{4}$ | $1\frac{1}{8}$ |
| 1 | $1\frac{1}{2}$ | $1\frac{1}{4}$ | $1\frac{1}{4}$ | $\frac{1}{4}$ | $1\frac{1}{4}$ |
| $1\frac{1}{8}$ | $1\frac{5}{8}$ | $1\frac{3}{8}$ | $1\frac{3}{8}$ | $\frac{1}{4}$ | $1\frac{3}{8}$ |
| $1\frac{1}{4}$ | $1\frac{3}{4}$ | $1\frac{1}{2}$ | $1\frac{5}{8}$ | $\frac{3}{8}$ | $1\frac{5}{8}$ |
| $1\frac{1}{2}$ | 2 | $1\frac{3}{4}$ | $1\frac{7}{8}$ | $\frac{1}{2}$ | $1\frac{7}{8}$ |
| $1\frac{3}{4}$ | $2\frac{1}{4}$ | 2 | $2\frac{1}{4}$ | $\frac{1}{2}$ | $2\frac{1}{4}$ |
| 2 | $2\frac{1}{2}$ | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $\frac{1}{2}$ | $2\frac{1}{2}$ |

Column A in the table gives the diameter of the bolts in inches or parts of an inch; column B the distance from the outside of metal to centre of bolt-holes; column C, from centre of bolts to periphery of flange; columns D and F, thickness of flanges; and column E, distance between the two flanges when they are face to face.

The flanges in Armstrong's cast-iron pipes, joints and wrought-iron hydraulic joints, should always be made oval—not with straight sides, as some makers give them. The oval form gives more strength across the centre of the bolt holes, with the same weight of metal.

The holes in the pipe flanges are usually made rectangular, and cast in the flanges. They should be $\frac{1}{8}$ inch wider and about $\frac{1}{4}$ inch longer than the diameter of the bolt. Some makers have the holes even larger; for instance, for $1\frac{1}{4}$ inch bolts the holes are $1\frac{1}{2}$ inch by $1\frac{5}{8}$ inch long.

Some do not face the flanges straight across; only make finished facings about $\frac{1}{8}$ inch deep. This facing should be of the same diameter as the distance between the inside of the bolt-holes in the flange. The space left by the facings on the flanges and the pacing is useful when the joint has to be broken; steel wedges can be driven in to loosen the joint.

## TABLE VII.

### Outside Diameter of Gas and Hydraulic Pipes.

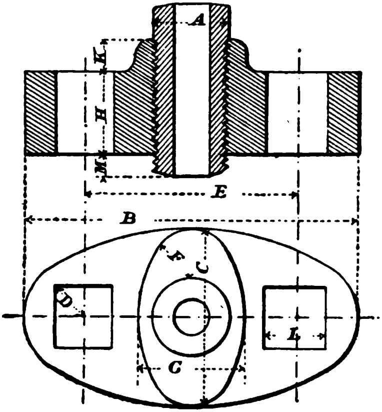
| Bore. | Gas pipe outside diameter. | Hydraulic outside diameter. | Bore. | Gas pipe outside diameter. | Hydraulic outside diameter. |
|---|---|---|---|---|---|
| Inch. | Inches. | Inches. | Inches. | Inches. | Inches. |
| $\frac{1}{2}$ | $\frac{13}{16}$ full | $1\frac{1}{16}$ bare | 2 | $2\frac{5}{16}$ full | $2\frac{9}{16}$ full |
| $\frac{3}{4}$ | $1\frac{1}{16}$ bare | $1\frac{5}{16}$ | $2\frac{1}{4}$ | $2\frac{9}{16}$ full | 3 |
| 1 | $1\frac{5}{16}$ | $1\frac{5}{8}$ full | $2\frac{1}{2}$ | 3 | $3\frac{1}{4}$ |
| $1\frac{1}{4}$ | $1\frac{5}{8}$ full | $1\frac{7}{8}$ | $2\frac{3}{4}$ | $3\frac{1}{4}$ | $3\frac{1}{2}$ |
| $1\frac{1}{2}$ | $1\frac{7}{8}$ | $2\frac{1}{16}$ bare | 3 | $3\frac{1}{2}$ bare | $3\frac{11}{16}$ full |
| $1\frac{3}{4}$ | $2\frac{1}{16}$ bare | $2\frac{5}{16}$ | | | |

The lead or wrought-iron rings for joints, as illustrated in Fig. 181, should be made $\frac{1}{8}$ inch thick, and the width of them should be such that when the ring is lapped with flannel and dipped in Stockholm tar it should fit comfortably between the bolts when put in, keeping them central with the bore of the pipe.

## TABLE VIII.

### Proportions of Heavy Oval Cast-Iron Flanges.

Fig. 197**.



| Bore. | A | B | C | D | E | F | G | H | K | L | M | Size of Bolts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| $\frac{1}{2}$ | $\frac{13}{16}$ | $3\frac{1}{2}$ | $1\frac{3}{4}$ | $\frac{5}{8}$ | $2\frac{1}{4}$ | $\frac{7}{16}$ | $1\frac{1}{8}$ | $\frac{7}{8}$ | $\frac{1}{4}$ | $\frac{9}{16}$ | $\frac{1}{8}$ | $\frac{1}{2}$ |
| $\frac{5}{8}$ | $1\frac{1}{16}$ | 5 | $2\frac{1}{2}$ | $\frac{13}{16}$ | $3\frac{1}{2}$ | $\frac{5}{8}$ | $1\frac{3}{4}$ | $1\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{11}{16}$ | $\frac{1}{8}$ | $\frac{5}{8}$ |
| $\frac{3}{4}$ | $1\frac{5}{16}$ | $5\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{7}{8}$ | $3\frac{3}{4}$ | $\frac{3}{4}$ | 2 | $1\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{11}{16}$ | $\frac{3}{16}$ | $\frac{5}{8}$ |
| 1 | $1\frac{9}{16}$ | $6\frac{1}{4}$ | 3 | $\frac{7}{8}$ | $4\frac{1}{8}$ | $\frac{7}{8}$ | $2\frac{1}{4}$ | $1\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{13}{16}$ | $\frac{3}{16}$ | $\frac{3}{4}$ |
| $1\frac{1}{4}$ | $1\frac{7}{8}$ | $6\frac{1}{2}$ | $3\frac{1}{2}$ | 1 | $4\frac{1}{2}$ | 1 | $2\frac{5}{8}$ | $1\frac{5}{8}$ | $\frac{5}{8}$ | $\frac{13}{16}$ | $\frac{1}{4}$ | $\frac{3}{4}$ |
| $1\frac{1}{2}$ | $2\frac{1}{16}$ | $7\frac{1}{4}$ | 4 | $1\frac{1}{8}$ | $5\frac{1}{8}$ | $1\frac{1}{8}$ | 3 | $1\frac{3}{4}$ | $\frac{3}{4}$ | $\frac{15}{16}$ | $\frac{1}{4}$ | $\frac{7}{8}$ |
| $1\frac{3}{4}$ | $2\frac{5}{16}$ | $8\frac{1}{4}$ | $4\frac{1}{2}$ | $1\frac{1}{4}$ | $5\frac{3}{4}$ | $1\frac{5}{16}$ | $3\frac{1}{2}$ | $1\frac{7}{8}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | $\frac{5}{16}$ | $\frac{7}{8}$ |
| 2 | $2\frac{9}{16}$ | 9 | 5 | $1\frac{13}{16}$ | $6\frac{1}{2}$ | $1\frac{3}{4}$ | 4 | 2 | 1 | $1\frac{1}{16}$ | $\frac{3}{8}$ | 1 |

These flanges are suitable for pressures up to about 1500 lbs. per square inch.

## TABLE IX.

### PROPORTIONS OF LIGHT OVAL CAST-IRON FLANGES.

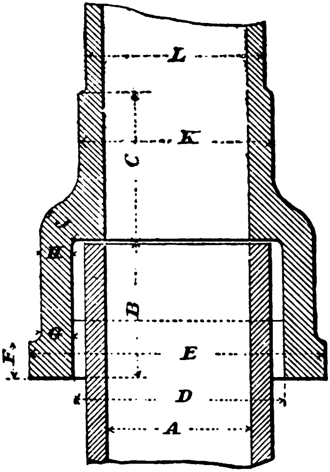
Same illustration as Table VIII.

| Bore. | A | B | C | D | E | F | G | H | K | L | M | Size of Bolts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| 1 | $1\frac{5}{16}$ | 5 | $2\frac{1}{2}$ | $\frac{13}{16}$ | $3\frac{1}{2}$ | $\frac{5}{8}$ | $1\frac{3}{4}$ | $\frac{3}{4}$ | $\frac{1}{4}$ | $\frac{11}{16}$ | $\frac{3}{16}$ | $\frac{5}{8}$ |
| $1\frac{1}{4}$ | $1\frac{9}{16}$ | $5\frac{1}{2}$ | $2\frac{3}{4}$ | $\frac{7}{8}$ | $3\frac{3}{4}$ | $\frac{3}{4}$ | 2 | $\frac{7}{8}$ | $\frac{1}{4}$ | $\frac{11}{16}$ | $\frac{1}{4}$ | $\frac{5}{8}$ |
| $1\frac{1}{2}$ | $1\frac{15}{16}$ | $6\frac{1}{4}$ | 3 | $\frac{7}{8}$ | $4\frac{1}{8}$ | $\frac{7}{8}$ | $2\frac{1}{4}$ | $\frac{7}{8}$ | $\frac{3}{8}$ | $\frac{13}{16}$ | $\frac{1}{4}$ | $\frac{3}{4}$ |
| $1\frac{3}{4}$ | $2\frac{1}{16}$ | $6\frac{1}{2}$ | $3\frac{1}{2}$ | 1 | $4\frac{1}{2}$ | 1 | $2\frac{5}{8}$ | $1\frac{1}{8}$ | $\frac{3}{8}$ | $\frac{13}{16}$ | $\frac{1}{4}$ | $\frac{3}{4}$ |
| 2 | $2\frac{5}{16}$ | $7\frac{1}{4}$ | 4 | $1\frac{1}{8}$ | $5\frac{1}{8}$ | $1\frac{1}{8}$ | 3 | $1\frac{1}{4}$ | $\frac{7}{16}$ | $\frac{15}{16}$ | $\frac{1}{4}$ | $\frac{7}{8}$ |
| $2\frac{1}{2}$ | $2\frac{15}{16}$ | $8\frac{1}{4}$ | $4\frac{1}{2}$ | $1\frac{1}{4}$ | $5\frac{3}{4}$ | $1\frac{5}{16}$ | $3\frac{1}{2}$ | $1\frac{3}{8}$ | $\frac{9}{16}$ | $\frac{15}{16}$ | $\frac{1}{4}$ | $\frac{7}{8}$ |

## TABLE X.

### Socket Pipes (not turned and bored).

Fig. 197***

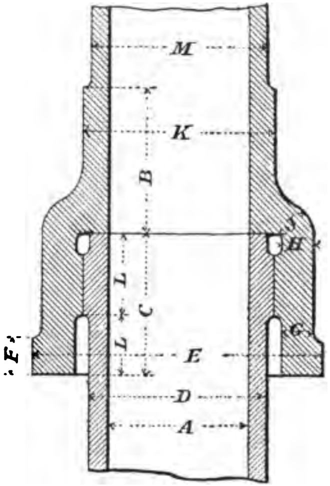


| A | B | C | D | E | F | G | H | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| 2 | 3 | 3 | 3¼ | 5 | ¾ | 11/16 | ⅝ | ¾ | 3 | 2¾ |
| 3 | 3 | 3 | 4¼ | 6 | ¾ | 11/16 | ⅝ | ¾ | 4 | 3¾ |
| 4 | 3 | 3 | 5¼ | 7 | ¾ | 11/16 | ⅝ | ¾ | 5 | 4¾ |
| 5 | 3½ | 3½ | 6⅝ | 8⅝ | ⅞ | 13/16 | 11/16 | ⅞ | 6¼ | 5⅞ |
| 6 | 3½ | 3½ | 7⅝ | 9⅝ | ⅞ | 13/16 | 11/16 | ⅞ | 7¼ | 6⅞ |
| 7 | 3½ | 3½ | 8¾ | 10¾ | ⅞ | 13/16 | 11/16 | ⅞ | 8¼ | 8 |
| 8 | 4 | 4 | 9¾ | 12 | 1 | 13/16 | 11/16 | ⅞ | 9¼ | 9 |
| 9 | 4 | 4 | 10⅞ | 13⅛ | 1 | 13/16 | 11/16 | ⅞ | 10½ | 10⅛ |
| 12 | 4 | 4 | 14 | 16½ | 1 | 15/16 | 13/16 | 1⅛ | 13½ | 13¼ |
| 15 | 4½ | 4½ | 17⅛ | 19⅞ | 1⅛ | 1 1/16 | 15/16 | 1¼ | 16¾ | 16⅜ |
| 18 | 4½ | 4½ | 20⅜ | 23⅜ | 1¼ | 1⅛ | 1 | 1¼ | 20 | 19⅝ |
| 20 | 4½ | 4½ | 22½ | 25¾ | 1⅜ | 1¼ | 1⅛ | 1¼ | 22¼ | 21¾ |
| 24 | 5 | 5 | 26¾ | 30¼ | 1½ | 1⅜ | 1¼ | 1½ | 26¼ | 26 |
| 33 | 5½ | 5 | 35¾ | 37¾ | 1¾ | 1½ | 1⅜ | 1⅝ | 35⅝ | 35 |

## TABLE XI.

### SOCKET PIPES (Turned and Bored).

FIG. 197°.



| A | B | C | D | E | F | G | H | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. | Ins. |
| 2 | 3 | 3 | $3\frac{1}{4}$ | 5 | $\frac{3}{4}$ | $\frac{11}{16}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | 3 | $1\frac{1}{4}$ | $2\frac{3}{4}$ |
| 3 | 3 | 3 | $4\frac{1}{4}$ | 6 | $\frac{3}{4}$ | $\frac{11}{16}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | 4 | $1\frac{1}{4}$ | $3\frac{3}{4}$ |
| 4 | 3 | 3 | $5\frac{1}{4}$ | 7 | $\frac{3}{4}$ | $\frac{11}{16}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | 5 | $1\frac{1}{4}$ | $4\frac{3}{4}$ |
| 5 | $3\frac{1}{2}$ | $3\frac{1}{2}$ | $6\frac{5}{8}$ | $8\frac{5}{8}$ | $\frac{7}{8}$ | $\frac{13}{16}$ | $\frac{11}{16}$ | $\frac{7}{8}$ | $6\frac{1}{4}$ | $1\frac{3}{8}$ | $5\frac{7}{8}$ |
| 6 | $3\frac{1}{2}$ | $3\frac{1}{2}$ | $7\frac{5}{8}$ | $9\frac{5}{8}$ | $\frac{7}{8}$ | $\frac{13}{16}$ | $\frac{11}{16}$ | $\frac{7}{8}$ | $7\frac{1}{4}$ | $1\frac{3}{8}$ | $6\frac{7}{8}$ |
| 7 | $3\frac{1}{2}$ | $3\frac{1}{2}$ | $8\frac{3}{4}$ | $10\frac{3}{4}$ | $\frac{7}{8}$ | $\frac{13}{16}$ | $\frac{11}{16}$ | $\frac{7}{8}$ | $8\frac{1}{4}$ | $1\frac{3}{8}$ | 8 |
| 8 | 4 | 4 | $9\frac{3}{4}$ | 12 | 1 | $\frac{13}{16}$ | $\frac{11}{16}$ | $\frac{7}{8}$ | $9\frac{1}{4}$ | $1\frac{5}{8}$ | 9 |
| 9 | 4 | 4 | $10\frac{7}{8}$ | $13\frac{1}{8}$ | 1 | $\frac{13}{16}$ | $\frac{11}{16}$ | $\frac{7}{8}$ | $10\frac{1}{2}$ | $1\frac{5}{8}$ | $10\frac{1}{8}$ |
| 12 | $4\frac{1}{2}$ | $4\frac{1}{2}$ | 14 | $16\frac{1}{2}$ | 1 | $\frac{15}{16}$ | $\frac{13}{16}$ | 1 | $13\frac{1}{2}$ | $1\frac{3}{4}$ | $13\frac{1}{4}$ |

The taper of the bored portion is $\frac{1}{32}$ inch per inch in length.

## TABLE XII.

### Weight of Wrought-iron Pipes per foot run.

| Bore. | Thickness of metal in parts of an inch. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $\frac{1}{16}$ | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ |
| Inches. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| $\frac{1}{4}$ | ·21 | ·5 | ·9 | 1·3 | 1·9 | 2·5 | 3·1 | 3·9 |
| $\frac{3}{8}$ | ·3 | ·7 | 1·1 | 1·6 | 2·3 | 2·9 | 3·8 | 4·6 |
| $\frac{1}{2}$ | ·4 | ·83 | 1·4 | 2·0 | 2·7 | 3·5 | 4·3 | 5·3 |
| $\frac{5}{8}$ | ·46 | 1·1 | 1·6 | 2·3 | 3·1 | 3·9 | 4·9 | 5·9 |
| $\frac{3}{4}$ | ·54 | 1·2 | 1·9 | 2·6 | 3·5 | 4·5 | 5·5 | 6·6 |
| $\frac{7}{8}$ | ·6 | 1·3 | 2·1 | 2·9 | 3·9 | 4·9 | 6·1 | 7·3 |
| 1 | ·7 | 1·5 | 2·4 | 3·3 | 4·3 | 5·5 | 6·7 | 7·9 |
| 1$\frac{1}{4}$ | ·87 | 1·8 | 2·9 | 3·9 | 5·2 | 6·4 | 7·8 | 9·3 |
| 1$\frac{1}{2}$ | 1·0 | 2·1 | 3·3 | 4·7 | 5·9 | 7·4 | 8·9 | 10·6 |
| 1$\frac{3}{4}$ | 1·2 | 2·5 | 3·8 | 5·3 | 6 8 | 8·4 | 10·1 | 11·9 |
| 2 | 1·4 | 2·8 | 4·3 | 5·9 | 7·6 | 9·5 | 11·3 | 13·2 |
| 2$\frac{1}{4}$ | 1·53 | 3·1 | 4·8 | 6·6 | 8·5 | 10·4 | 12·4 | 14·5 |
| 2$\frac{1}{2}$ | 1·7 | 3·5 | 5·3 | 7·3 | 9·3 | 11·4 | 13·6 | 15·9 |
| 2$\frac{3}{4}$ | 1·9 | 3·8 | 5·8 | 7·9 | 10·1 | 12·4 | 14·7 | 17·2 |
| 3 | 2·03 | 4·1 | 6·3 | 8·6 | 10·9 | 13·3 | 15·9 | 18·5 |

## TABLE XIII.

### Weight of Large Welded Wrought-iron Pipes per foot run. Made in lengths up to 14 feet 6 inches.

| Bore. | Thickness of Pipe. | | | | Bore. | Thickness of Pipe. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ |
| Ins. | lbs. | lbs. | lbs. | lbs. | Ins. | lbs. | lbs. | lbs. | lbs. |
| 10 | 20 | 26 | 33 | 40 | 18 | 35 | 47 | 59 | 72 |
| 11 | 22 | 29 | 37 | 44 | 19 | 37 | 50 | 63 | 76 |
| 12 | 24 | 32 | 40 | 48 | 20 | 39 | 53 | 66 | 80 |
| 13 | 26 | 34 | 43 | 52 | 21 | 41 | 55 | 69 | 84 |
| 14 | 28 | 37 | 47 | 56 | 22 | 43 | 58 | 73 | 88 |
| 15 | 30 | 40 | 50 | 60 | 23 | 45 | 61 | 76 | 92 |
| 16 | 32 | 42 | 53 | 64 | 24 | 47 | 63 | 79 | 96 |
| 17 | 33 | 45 | 56 | 68 | | | | | |

## TABLE XIV.

WEIGHT OF RIVETED WROUGHT-IRON PIPES per foot run.
Made in lengths up to 25 feet.

| Bore. | Thickness of Pipe. | | | | | Bore. | Thickness of Pipe. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ |
| Ins. | lbs. | lbs. | lbs. | lbs. | lbs. | Ins. | lbs. | lbs. | lbs. | lbs. | lbs. |
| 12 | 19 | 29 | 38 | 48 | 58 | 30 | 44 | 66 | 89 | 112 | 134 |
| 15 | 23 | 34 | 46 | 59 | 71 | 36 | 53 | 79 | 105 | 133 | 159 |
| 18 | 28 | 41 | 55 | 70 | 84 | 42 | 61 | 92 | 122 | 153 | 184 |
| 24 | 36 | 54 | 72 | 91 | 109 | 48 | 70 | 104 | 139 | 161 | 200 |

## TABLE XV.

WEIGHT OF ANGLE-IRON RINGS RIVETED ON PIPES, as illustrated in Fig. 193.

| Bore of Pipe. | Sizes of Angle Iron. | | | |
|---|---|---|---|---|
| | $2\times2\times\frac{3}{8}$ | $2\frac{1}{2}\times2\frac{1}{2}\times\frac{3}{8}$ | $3\times3\times\frac{1}{2}$ | $3\frac{1}{2}\times3\frac{1}{2}\times\frac{5}{8}$ |
| | Weight of each ring in lbs. | | | |
| Inches. | | | | |
| 10 | 15 | 20 | 36 | 51 |
| 11 | 16 | 22 | 39 | 54 |
| 12 | 18 | 23 | 41 | 58 |
| 13 | 19 | 25 | 44 | 61 |
| 14 | 20 | 26 | 47 | 65 |
| 15 | 21 | 28 | 49 | 68 |
| 16 | 22 | 29 | 52 | 72 |
| 17 | 24 | 31 | 55 | 75 |
| 18 | 25 | 32 | 57 | 79 |
| 19 | 26 | 34 | 60 | 82 |
| 20 | 27 | 35 | 62 | 86 |
| 21 | 28 | 37 | 65 | 89 |
| 22 | 30 | 38 | 68 | 93 |
| 23 | 31 | 40 | 70 | 96 |
| 24 | 32 | 41 | 73 | 100 |

## TABLE XVI.

### WEIGHT OF STEEL SOCKETS RIVETED ON PIPES, as illustrated in Fig. 194.

| Bore of Pipe. | Weight of Socket. | Bore of Pipe. | Weight of Socket. | Bore of Pipe. | Weight of Socket. |
|---|---|---|---|---|---|
| Inches. | lbs. | Inches. | lbs. | Inches. | lbs. |
| 10 | 10 | 15 | 16 | 20 | 32 |
| 11 | 11 | 16 | 19 | 21 | 34 |
| 12 | 12 | 17 | 22 | 22 | 35 |
| 13 | 13 | 18 | 25 | 23 | 37 |
| 14 | 14 | 19 | 29 | 24 | 38 |

## TABLE XVII.

### WEIGHT OF LOOSE SOCKETS, as illustrated in Fig. 193.

| Bore of Pipe. | Weight of Socket. | Bore of Pipe. | Weight of Socket. | Bore of Pipe. | Weight of Socket. |
|---|---|---|---|---|---|
| Inches. | lbs. | Inches. | lbs. | Inches. | lbs. |
| 10 | 25 | 15 | 36 | 20 | 46 |
| 11 | 27 | 16 | 38 | 21 | 48 |
| 12 | 29 | 17 | 40 | 22 | 51 |
| 13 | 31 | 18 | 42 | 23 | 53 |
| 14 | 33 | 19 | 44 | 24 | 55 |

Riveted wrought-iron and steel pipes up to 24 inches diameter nest for shipment with a difference in diameter of 2 inches, large pipes with a difference of 3 inches. Welded pipes nest with a difference in diameter of 1 inch.

## PIPE-STAYS.

Pipe-stays are generally placed in mine shafts and wells, about 18 feet apart, that is one stay for every alternate length of pipe. They are made either of wood only, wood and wrought iron, and wrought iron and cast iron.

The simplest form consists of a baulk of timber secured across the well or pit shaft, a hollow being cut into one side of the baulk to fit the pipe. A short piece of timber, similarly hollowed out, is bolted to the baulk; by this means the pipe is firmly gripped. The stays are placed directly under the flange of the pipe or under one of the belts on the pipe, if belts are provided on them.

Frequently wrought-iron clips or straps are used, instead of the short piece of timber, which strap is secured by means of two bolts passing through the baulk of wood.

In some instances, particularly where three-throw deep-well pumps are employed, wrought-iron clips are secured to cast-iron girders, as illustrated at O, Fig. 161. The wrought-iron clip, D, is bolted to the cast-iron girder, A, by the two bolts, K.

Small pipes, which are close to the side of the well, are fixed by simply driving staples into the joints between the bricks, similar to the ordinary pipe-hooks used by plumbers to secure ordinary water and gas pipes; at

## TABLE XVIII.

**Weight of Cast-Iron Flange Pipes** per foot run.

| Bore. | Thickness of Metal in parts of Inches. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 11/16 | 3/4 | 7/8 | 1 | 1 1/8 | 1 1/4 |
| Inches. | | | | | | | | | | | | | |
| 1 | 3·1 | 4·0 | 5·1 | 6·2 | 7·4 | 8·6 | 10·0 | 11·4 | 12·9 | 16·1 | 19·6 | 23·4 | 27·6 |
| 1 1/4 | 3·7 | 4·8 | 6·0 | 7·2 | 8·6 | 10·0 | 11·5 | 13·1 | 14·7 | 18·2 | 22·1 | 26·2 | 30·7 |
| 1 1/2 | 4·3 | 5·6 | 6·9 | 8·3 | 9·8 | 11·4 | 13·0 | 14·7 | 16·5 | 20·4 | 24·5 | 28·9 | 33·7 |
| 1 3/4 | 4·9 | 6·3 | 7·8 | 9·4 | 11·0 | 12·7 | 14·5 | 16·4 | 18·4 | 22·5 | 26·9 | 31·7 | 36·7 |
| 2 | .. | .. | 8·7 | 10·4 | 12·3 | 14·1 | 16·1 | 18·1 | 20·3 | 24·7 | 29·5 | 34·5 | 39·9 |
| 2 1/4 | .. | .. | 9·6 | 11·5 | 13·5 | 15·5 | 17·6 | 19·8 | 22·0 | 26·8 | 31·8 | 37·2 | 42·9 |
| 2 1/2 | .. | .. | 10·6 | 12·6 | 14·7 | 16·9 | 19·1 | 21·5 | 23·9 | 28·9 | 34·3 | 40·0 | 45·9 |
| 2 3/4 | .. | .. | 11·5 | 13·7 | 16·0 | 18·3 | 20·7 | 23·2 | 25·7 | 31·1 | 36·8 | 42·7 | 49·0 |
| 3 | .. | .. | 12·4 | 14·7 | 17·1 | 19·6 | 22·2 | 24·8 | 27·6 | 33·3 | 39·3 | 45·5 | 52·0 |
| 3 1/4 | .. | .. | 13·3 | 15·8 | 18·4 | 21·0 | 23·7 | 26·5 | 29·4 | 35·4 | 41·6 | 48·2 | 55·1 |
| 3 1/2 | .. | .. | 14·2 | 16·9 | 19·6 | 22·4 | 25·3 | 28·2 | 31·2 | 37·5 | 44·1 | 51·0 | 58·2 |
| 3 3/4 | .. | .. | 15·2 | 18·0 | 20·8 | 23·8 | 26·8 | 29·9 | 33·1 | 39·7 | 46·6 | 53·8 | 61·3 |
| 4 | .. | .. | 16·1 | 19·0 | 22·1 | 25·1 | 28·3 | 31·6 | 35·0 | 41·9 | 49·1 | 56·5 | 64·3 |
| 4 1/4 | .. | .. | 17·0 | 20·1 | 23·3 | 26·6 | 30·0 | 33·3 | 36·8 | 44·0 | 51·5 | 59·3 | 67·4 |
| 4 1/2 | .. | .. | 17·9 | 21·2 | 24·5 | 27·9 | 31·4 | 34·9 | 38·6 | 46·1 | 53·9 | 62·0 | 70·4 |
| 4 3/4 | .. | .. | 18·8 | 22·3 | 25·7 | 29·3 | 33·0 | 36·6 | 40·4 | 48·2 | 56·3 | 64·8 | 73·5 |
| 5 | .. | .. | 19·8 | 23·3 | 26·9 | 30·7 | 34·4 | 38·3 | 42·3 | 50·5 | 58·8 | 65·7 | 76·6 |
| 5 1/4 | .. | .. | 20·7 | 24·4 | 28·2 | 32·0 | 36·0 | 40·0 | 44·1 | 52·5 | 61·3 | 70·3 | 79·7 |
| 5 1/2 | .. | .. | 21·6 | 25·5 | 29·4 | 33·5 | 37·5 | 41·7 | 46·0 | 54·7 | 63·7 | 73·1 | 82·7 |
| 5 3/4 | .. | .. | 22·5 | 26·6 | 30·6 | 34·8 | 39·1 | 43·4 | 47·8 | 56·8 | 66·2 | 75·8 | 85·8 |
| 6 | .. | .. | 23·4 | 27·6 | 31·9 | 36·2 | 40·6 | 45·0 | 49·7 | 59·1 | 68·7 | 78·7 | 89·0 |
| 6 1/4 | .. | .. | 24·4 | 28·7 | 33·1 | 37·6 | 42·9 | 46·8 | 51·5 | 61·1 | 71·1 | 81·3 | 92·0 |
| 6 1/2 | .. | .. | 25·3 | 29·7 | 34·3 | 38·9 | 44·2 | 48·4 | 53·3 | 63·2 | 73·5 | 84·1 | 95·0 |
| 6 3/4 | .. | .. | 26·2 | 30·8 | 35·5 | 40·3 | 45·2 | 50·1 | 55·1 | 65·4 | 76·0 | 86·8 | 98·0 |
| 7 | .. | .. | 27·1 | 31·9 | 36·8 | 41·7 | 46·7 | 51·8 | 56·8 | 67·7 | 78·5 | 89·7 | 101·2 |
| 7 1/4 | .. | .. | 28·0 | 32·9 | 37·7 | 43·1 | 48·2 | 53·5 | 58·8 | 69·7 | 80·9 | 92·4 | 104·1 |
| 7 1/2 | .. | .. | 29·0 | 34·0 | 39·2 | 44·5 | 49·8 | 55·2 | 60·7 | 71·9 | 83·3 | 95·1 | 107·2 |

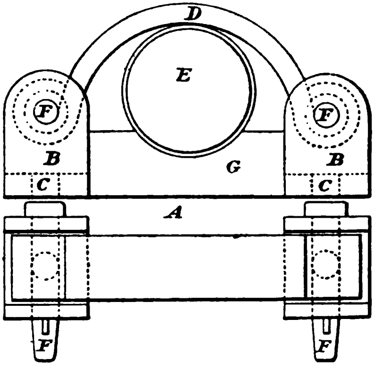
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7¾ | .. | .. | 29·9 | 35·1 | 40·4 | 45·8 | 51·3 | 56·8 | 62·5 | 74·0 | 85·8 | 97·9 | 110·3 |
| 8 | .. | .. | 30·8 | 36·2 | 41·6 | 47·1 | 52·8 | 58·5 | 64·3 | 76·2 | 88·4 | 100·8 | 113·5 |
| 8½ | .. | .. | 32·8 | 38·2 | 44·1 | 50·0 | 56·0 | 61·9 | 68·0 | 80·4 | 93·1 | 106·1 | 119·5 |
| 9 | .. | .. | 34·4 | 40·5 | 46·6 | 52·7 | 58·9 | 65·3 | 71·7 | 84·8 | 98·2 | 111·8 | 125·8 |
| 9½ | .. | .. | 36·3 | 42·6 | 49·0 | 55·5 | 62·0 | 68·6 | 75·3 | 89·1 | 102·7 | 117·1 | 131·4 |
| 10 | .. | .. | 38·2 | 44·7 | 52·4 | 58·2 | 65·1 | 72·9 | 79·0 | 93·3 | 108·0 | 122·9 | 138·1 |
| 10½ | .. | .. | 40·0 | 46·8 | 53·7 | 60·9 | 68·0 | 75·2 | 82·4 | 97·4 | 112·7 | 128·3 | 143·9 |
| 11 | .. | .. | 41·9 | 48·9 | 56·4 | 63·6 | 71·0 | 78·5 | 86·4 | 101·8 | 117·8 | 133·9 | 150·3 |
| 11½ | .. | .. | 43·7 | 51·2 | 59·0 | 66·5 | 74·3 | 82·1 | 90·2 | 106·1 | 122·6 | 139·2 | 156·3 |
| 12 | .. | .. | 45·6 | 53·4 | 61·4 | 69·3 | 77·3 | 85·8 | 93·7 | 110·4 | 127·4 | 145·0 | 162·6 |
| 12½ | .. | .. | .. | .. | 63·6 | 72·1 | 80·2 | 88·9 | 97·3 | 114·5 | 132·3 | 150·2 | 168·5 |
| 13 | .. | .. | .. | .. | 66·1 | 74·6 | 83·3 | 92·0 | 101·1 | 118·9 | 137·3 | 155·7 | 174·4 |
| 13½ | .. | .. | .. | .. | 68·6 | 77·4 | 86·4 | 95·5 | 104·8 | 123·2 | 142·0 | 161·3 | 180·6 |
| 14 | .. | .. | .. | .. | 71·2 | 80·2 | 89·6 | 98·9 | 108·4 | 127·5 | 147·0 | 167·1 | 187·2 |
| 14½ | .. | .. | .. | .. | 73·3 | 86·0 | 92·7 | 102·3 | 111·2 | 131·7 | 149·9 | 172·2 | 192·8 |
| 15 | .. | .. | .. | .. | 76·1 | 85·8 | 95·9 | 105·5 | 115·7 | 136·1 | 156·8 | 177·7 | 199·4 |
| 15½ | .. | .. | .. | .. | 78·6 | 88·6 | 99·0 | 109·2 | 119·5 | 140·7 | 161·9 | 183·5 | 205·3 |
| 16 | .. | .. | .. | .. | 81·0 | 91·4 | 102·0 | 112·6 | 123·2 | 144·7 | 166·6 | 188·7 | 211·7 |
| 16½ | .. | .. | .. | .. | 83·3 | 93·9 | 104·8 | 115·8 | 126·7 | 148·8 | 171·6 | 194·4 | 217·5 |
| 17 | .. | .. | .. | .. | 85·8 | 97·0 | 108·0 | 119·2 | 130·7 | 153·5 | 176·6 | 199·0 | 223·7 |
| 17½ | .. | .. | .. | .. | 88·3 | 99·5 | 111·1 | 122·6 | 134·2 | 157·6 | 181·3 | 205·3 | 229·6 |
| 18 | .. | .. | .. | .. | 90·8 | 102·3 | 114·3 | 126·0 | 137·9 | 161·9 | 186·2 | 210·9 | 236·2 |
| 18½ | .. | .. | .. | .. | 93·0 | 104·8 | 117·0 | 129·2 | 141·3 | 166·0 | 190·9 | 216·2 | 241·6 |
| 19 | .. | .. | .. | .. | 95·5 | 108·0 | 120·1 | 132·6 | 145·1 | 170·4 | 195·9 | 221·8 | 248·0 |
| 19½ | .. | .. | .. | .. | 98·0 | 110·8 | 123·2 | 136·0 | 148·8 | 174·7 | 200·9 | 227·4 | 255·5 |
| 20 | .. | .. | .. | .. | 100·5 | 113·3 | 126·5 | 139·5 | 152·3 | 178·9 | 205·8 | 232·9 | 260·3 |
| 20½ | .. | .. | .. | .. | .. | .. | 129·5 | 142·9 | 156·3 | 183·5 | 210·9 | 238·4 | 266·4 |
| 21 | .. | .. | .. | .. | .. | .. | 132·6 | 146·3 | 160·1 | 187·5 | 215·6 | 244·0 | 272·6 |
| 21½ | .. | .. | .. | .. | .. | .. | 135·4 | 149·4 | 163·5 | 191·9 | 220·6 | 249·6 | 278·6 |
| 22 | .. | .. | .. | .. | .. | .. | 138·8 | 152·9 | 167·2 | 197·1 | 225·4 | 254·9 | 284·8 |
| 22½ | .. | .. | .. | .. | .. | .. | 141·6 | 156·0 | 170·7 | 200·3 | 230·3 | 260·5 | 290·8 |
| 23 | .. | .. | .. | .. | .. | .. | 144·8 | 159·7 | 174·7 | 205·0 | 235·3 | 266·1 | 297·3 |
| 23½ | .. | .. | .. | .. | .. | .. | 147·9 | 162·9 | 178·2 | 209·0 | 240·2 | 271·4 | 303·3 |
| 24 | .. | .. | .. | .. | .. | .. | 151·2 | 166·6 | 182·5 | 213·9 | 245·0 | 276·9 | 309·3 |

The weight of the two flanges is usually reckoned equal to the weight of 1 foot of pipe.

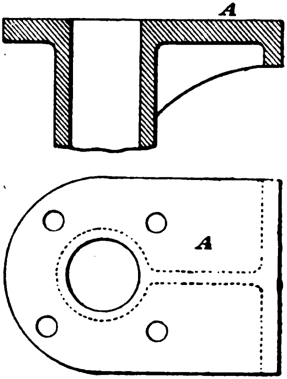
other times the staples are double-ended, forming the letter **U**.

Again, in Figs. 198 and 199, is shown an excellent example of a pipe-stay made of wrought iron bolted to a baulk of timber. It consists of two wrought-iron brackets, B, secured to the timber fixed in the sides of the pit shaft; C C are holes for bolts to secure the brackets; G is a piece of wood hollowed out to receive the pipe, E, which latter in this case was made of wrought iron. D is a wrought-iron strap, turned over at both ends, as shown in plan, Fig. 198, and held to the wrought-iron brackets, C C, by the pins, F F, which again are held in their places by cotters.

Figs. 198, 199.



Figs. 200, 201.



In a few odd cases the author has seen small cast-iron pipes secured to the side of the well by means of lugs cast on the pipe flanges, the latter being built into the stining of the well. This lug is shown at A in elevation and plan, Figs. 200 and 201.

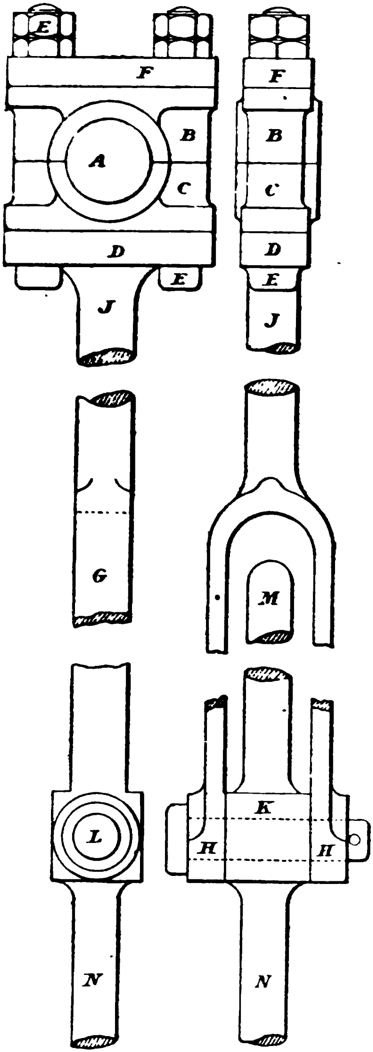
## PUMP-SLINGS, GUIDE-RODS, AND GUIDES.

### PUMP-SLINGS.

Pump-sling is the technical term for the forked rod connecting the cross-head on the top of the well or pump-rods with the pump-crank. There are several different designs of these rods, both with regard to the end connected to the crank-pin, and that end of the fork which is coupled to the cross-head on the guide-rod.

The cheapest and most common pump-sling is illustrated in Figs. 202 and 203. The end which connects to the crank-pin, or journal, in this example is usually termed the "marine end." A is the bore for the journal; B and C are the gun-metal steps, which are carefully faced at the joint and sides, and bored out and scraped to fit the journal, the ends of the bore being carefully rounded to the same radius as the journal. D is the top of the wrought-iron or mild-steel sling, formed to the shape of a T, and secured to the gun-metal steps by the two bolts E E. For bucket-lifts a wrought-iron or steel plate, F, must be placed on the top of the gun-metal step, B, between it and the nuts on the bolts, as the strain in such cases is always on the bolts and the top step. In plunger-pumps, the thrust being downwards, there is no need for the plate, or keep, as it is frequently termed. The bottom part, G, of the sling is made fork-shaped, as shown in Fig. 203, and into this fork projects the guide-rod. The extreme ends of the fork are formed into bosses, H H, bored out to form bearings for the cross-head

FIG. 202. FIG. 203.



pin. The part, J, between the fork, G, and the T-head, D, is usually round, although in some cases it is made flat, and in a few instances square. Sometimes in large pump-work the ends, H H, instead of being made solid, are fitted with gun-metal steps, wrought-iron straps, and steel or wrought-iron gibs and cotters, similar to the crank-journal end, Figs. 204 and 205.

Figs. 204 and 205 illustrate a sling having the crank-journal, A, fitted with a pair of gun-metal steps, B and C, wrought-iron strap, D, gib, E, and cotter, F, like an ordinary connecting-rod for a steam engine. This plan is preferable for bucket-lifts, although it is very seldom used on account of the great expense in fitting, while it is very little

FIG. 204.

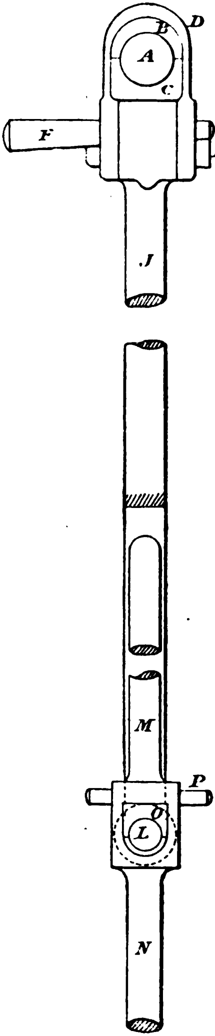
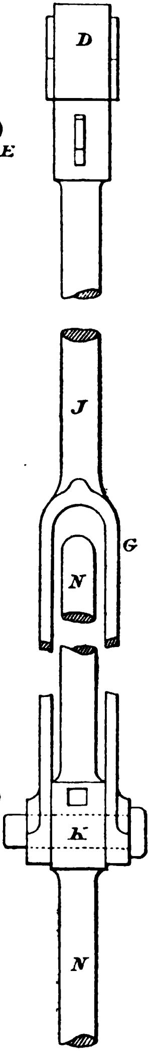


FIG. 205.

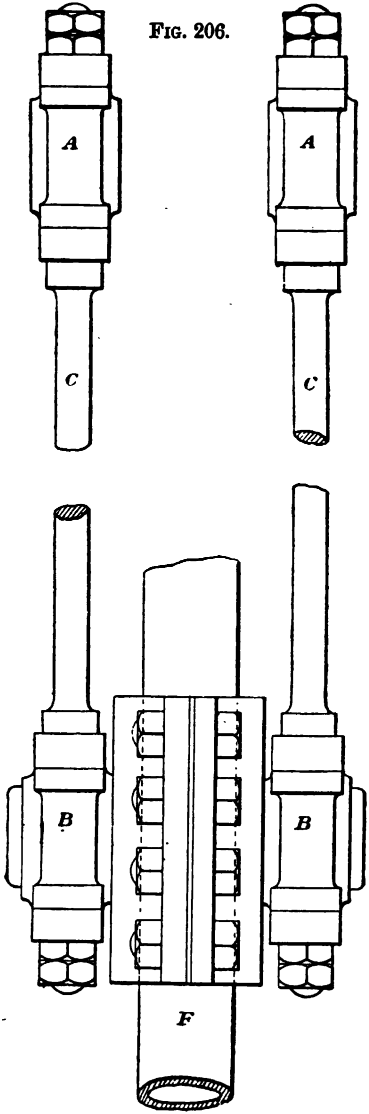


superior to the previously described. The fork-end and the remainder of the sling is made exactly like Figs. 202 and 203.

The crank-journal end of the sling for plunger-pumps may be made similar to the journal-end for top of tube-rods illustrated in Fig. 136. This type is very good and not very expensive to manufacture, the weak point being the cotter and gib, but they have only to lift the weight of the parts in the shaft when plunger-pumps are used, and if the gib and cotter are made of ample strength, there is, of course, no danger of breakage.

In one single instance the writer has had to design two single rods, instead of a forked sling. This arrangement is illustrated in Fig. 206, each rod consisting of two marine-rod ends, A and B, connected by the two bolts, C. This was

FIG. 206.



used for one bucket-lift, worked by means of a single crank, which latter was made with a very long journal to take the two heads, A A, and a space between them equal to the width of the cross-head, which latter will be explained further on. This plan is not to be recommended for two- or three-throw pumps, because it will make the distance between the crank-journals very great, whereas they ought to be kept as small as possible, to prevent the crank from vibrating, without making them excessively heavy. Of course, there might be a journal between each crank, but this will necessitate a very large well or shaft, on account of the great distance required for the additional journals.

## GUIDE-RODS.

Guide-rods are usually made in one with the top end of the pump- or well-rods, and furnished with a cross-head forged solid on the rod, the latter being machined to fit in the fork of the sling. In some instances, especially in cheap work, the cross-head is simply bored out to fit the cross-head pin, but in first-class work it is fitted with a pair of gun-metal steps, when the sling-ends are not fitted with gun-metal steps, straps, gibs, and cotters. Again, in some cases the cross-heads for solid rods are fitted on the rod and secured by a cotter. When tube-rods are used, the cross-head is clipped on by means of bolts.

A guide-rod, with solid cross-head, is illustrated in Figs. 202 and 203, K being the cross-head, L the cross-head pin, M guide-rod, N the top of the solid wrought-iron well-rod. When the bottom end of the sling, H, is fitted with gun-metal steps, the cross-head pin, L, is forged solid with the cross-head, and each end of the pin, or each pin, is fitted with a solid forged collar.

A solid cross-head and pins of forged steel for clipping a 4-inches diameter tube-rod is illustrated in end view, Fig. 206, front view, Fig. 207, and plan, Fig. 208. It consists of two forgings, D and E, bolted together, gripping the tube-rod, F, by means of eight bolts 1 inch in diameter, with square heads and nuts, the boss being 12 inches long, and 1 inch metal all round the tube; the lugs for the bolts are also 1 inch thick. Each half of the clip or cross-head is furnished with a cross-head pin, G and H, forged solid on the boss, the pins being 3 inches diameter by 5 inches long. The tube-rods in this example were 4 inches diameter externally, and 3 inches internally. The boss was bored out, and when bored was open $\frac{1}{8}$ inch between the lugs to allow them to grip the rod.

Fig. 207.

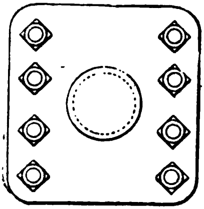
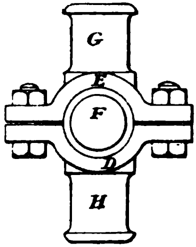


Fig. 208.

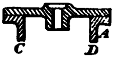


An example of a guide-rod, with a cross-head fitted with gun-metal steps, is illustrated in Figs. 204 and 205. In this example the guide-rod, M, and the well-rod, N, were both $1\frac{1}{2}$ inch diameter, the cross-head pin, L, $1\frac{3}{8}$ inch diameter; the width of the block, K, was 3 inches, same distance as between the two ends of the sling-fork; O are the gun-metal steps, and P the cotter for taking up the wear of the steps and pin.

## Guide-Brackets.

The brackets in which the guide-rods work are generally made in one of two ways. The one mostly used for small three-throw pumps is illustrated in cross-section, Fig. 209, plan, Fig. 210, and side-elevation, Fig. 211, consisting of a cast-iron girder, A, having an opening cast in the centre, at B, and furnished on the

FIG. 209.



FIGS. 212, 213.

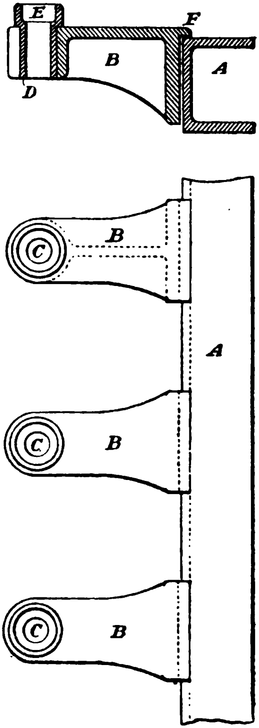


FIG. 210.

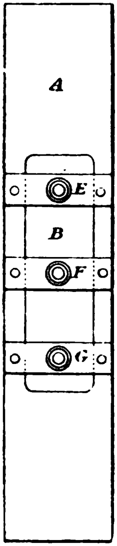
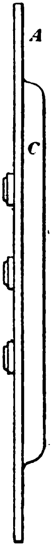


FIG. 211.



underside with two strengthening ribs, C and D, close to the sides of the opening, B. Across this opening is bolted to the guide-girder, A, one, two, or three cross-bars, E, F, and G, according to the number of pumps; these cross-bars are furnished at their centre with bosses, which bosses are, in common pumps, bored out to fit the pump-rods, but in first-class work the bosses are fitted with gun-metal bushes, the top of which are formed into a cup-shape, to hold lubricants, such as oil or tallow. The girder, A, is securely bedded into the sides of the well or shaft to a depth of about 9 inches, which sides usually are made of brickwork at that part of the well.

Another style of guide is illustrated in cross-section, Fig. 212, and plan, Fig. 213. A is a cast-iron or wrought-iron girder of channel section, built into the brickwork at the top of the well. To this is bolted a cast-iron bracket, B, for each rod, C, according to the number of pumps. These brackets are chipped or planed to fit planed facings on the cast-iron girder, and bored out to receive the gun-metal bush, D, furnished at the top with a cup, E, for holding lubricants. Usually the foot of the bracket is furnished with a lip, F, to relieve the bolts from any undue strain.

## REMARKS ON DESIGNING PUMP-SLINGS, GUIDE-RODS, AND GUIDE-BRACKETS.

The collective area of the two bolts in the marine ends of the slings, Figs. 202 and 203, when used for bucket-pumps, should equal in area the well-rod for which they are used.

The bolts should be fitted with nuts and split-pins, or double-nuts, and the heads are usually made cheese-shaped.

In example, Fig. 206, when used for plunger-pumps, the bolts, C, should be swelled in the middle to prevent them from buckling, especially if the centres of the crank-pin and cross-head-pin are great.

The greater the distance between the centres of the slings the less the strain on the guide-rods, therefore the slings should be made as long as practicable, for 18 inches stroke they are made about 6 feet, or four times the length of the stroke.

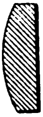
The length of the fork must be at least equal to the length of the stroke of the pump, plus the depth of the guide and half the distance between the two ends of the fork.

The length of the part J, Figs. 202 and 203, of the sling must be such as to clear the web of the pump-crank or the periphery of the crank-disc, as the case may be.

The strength of the fork for bucket-lifts must be equal to the strength of the well-rod, but for plunger-pumps of shallow wells, where the weight of the working parts is not sufficient to force the water up, an allowance must be made to prevent buckling.

The cross-section of the fork is sometimes made rectangular; this is a very expensive section, when the fork has to be got up bright; the section shown in Fig. 214 is the best, for they can then be turned in the lathe, the curve being the radius struck from the centre line to the outside face of the fork. Generally only the top part of the sling that works above the engine-house floor is polished bright.

FIG. 214.



The length of the guide-rod must be the same as the length of the stroke, the depth of the guide-bush, and the clearance at top and bottom, which varies from 1 inch to 2 inches.

The diameter of the guide-rods is invariably the same as the diameter of the well-rods, but they ought to be made a little larger to compensate for wear.

The cross-head pin, when brasses are fitted into the cross-head, should be keyed or pinned into one end of the sling-fork to prevent the pin from working round in the plain bosses, and when the fork-ends are fitted with brasses, and the cross-head pin is not forged solid with the cross-head, the pin should be keyed or cottered into the cross-head.

The guide-brackets ought always to be fitted with gun-metal bushes, as illustrated in Figs. 212 and 213, because the side-wear is great, especially when the slings are short; when they are bushed, a new bush can soon be substituted, whereas otherwise a new cast-iron bracket must be put in the place of the one that is worn out.

# KITES, YOKES, AND CONNECTING-RODS.

## KITES.

The kite or bow is the usual name for the frame that couples together the steam and water cylinders piston-rods in steam pumps, and guide-rod and pump-rod in hand and power-pumps. They are made in a variety of different shapes, of cast iron, cast malleable iron, wrought iron, and cast steel.

FIG. 215.

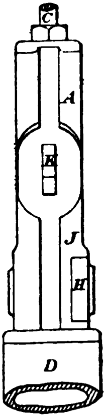
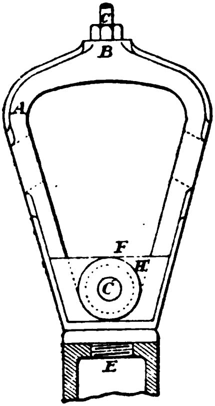
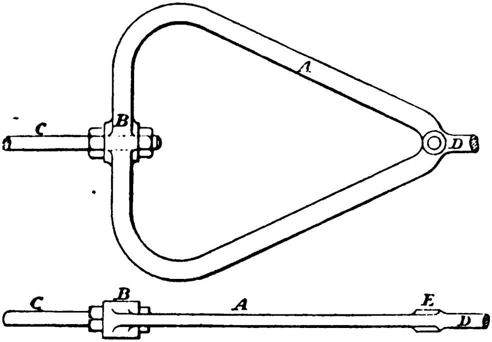


FIG. 216.



One design of kite is illustrated in Figs. 215 and 216. A is the bow itself, furnished with a boss, B, into which the steam piston rod, C, is secured, and the plunger, D, is screwed on the boss, E. F forms the cross-head into which the cross-head pin, G, is screwed, and prevented from getting loose by a nut; the plate, H, is let into the bow, held and secured by the cross-head pin; both the holes in the plate, H, and the bow, at J, are carefully bored out to fit the pin. These bows are made of cast malleable iron or cast steel. When they are used for small plunger-pumps they are of cast iron, with the plunger cast in one with it. Again, when the pump is of the double-acting piston type, instead of the projecting boss, E, there is a boss, like B, provided, and the pump-rod secured in the same manner as the piston-rod, C. The steam piston-rod and pump-rod or plunger, as the case may be, ought to be roughed out and screwed, secured to the bow, and the whole put into the lathe and turned to the required size, to be certain that all are made perfectly true and in a straight line. K are slot holes into which the cotter of the connecting-rod works, the connecting-rod being of the type illustrated in Figs. 225 and 227.

Figs. 217, 218.

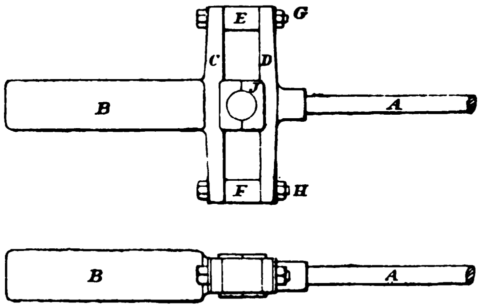


A wrought-iron kite or bow for a set of three-throw hand-force pumps, 2½ inches diameter by 8 inches length of stroke, is illustrated in elevation, Fig. 217, and plan, Fig. 218, in which A is the bow, B a boss into which the pump-rod, C, is secured by a nut on each end of the boss; D is the guide rod, $\frac{7}{8}$ inch diameter; E is the boss formed to receive the cross-head pin for the connecting rod. It will be seen that the bow or kite is made of flat bar-iron.

## Yokes, or Slotted Links.

Yoke or slotted link is the term used for the connection between the steam piston-rod, or guide-rod in some cases, and the pump-rod or plunger, which connection also takes the place of the connecting-rod. The yoke or slotted link—a name given on account of it being originally made solid and slotted out—in fact, it is yet sometimes made solid, as will be explained further on—has for many years been a favourite with numerous pump manufacturers; it enables them to do away with the connecting-rod, and thus to make a very compact pump with a minimum number of parts. It is also a better method of driving the pump-piston or plunger than by a crank and connecting-rod, because it imparts to the pump-piston a more uniform motion, as the first half of the out-stroke of the

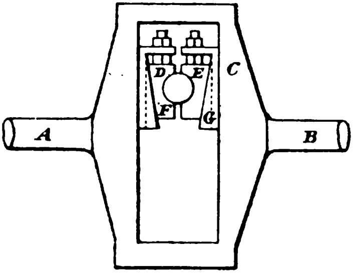
Figs. 219, 220.



yoke corresponds to the first quarter of the revolution, whereas with a connecting-rod each quarter of the revolution of the crank corresponds with more or less than one-half of the stroke of the piston. Its work is very little, practically not much more than is required to move the valve and turn the fly-wheel over, and hence there is little strain upon the crank-shaft and crank-pin.

Fig. 219 is an elevation, and Fig. 220 a plan, of a very simple and good slotted link for a fly-wheel donkey-pump. A is the steam piston-rod, B the pump-plunger, C and D are two cross-heads or bars; C is in this case cast in one with the plunger, and D is secured to the steam piston-rod by a cotter into the boss; E and F are two distance-blocks, through which pass the two bolts, G and H, uniting the whole, so as to form one yoke or slotted link. The cross-head for large pumps is made of steel or cast malleable iron, and for very heavy work of wrought iron. For small pumps they are frequently forged in one with the steam piston and pump-rods, faced in the lathe, then bolted together and the rods turned, to ensure accuracy. In the slotted link works a guide-block or shoe, J, which should be made of gun-metal, although for cheapness they are frequently made of cast iron. Some makers have a

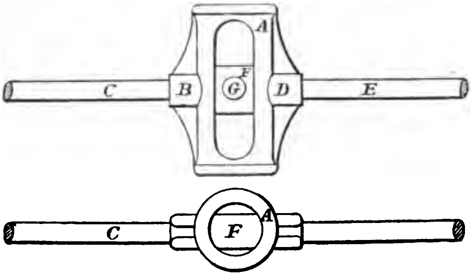
FIG. 221.



notion that rollers are better, as they create less friction, but the wear and tear of the roller and links is fearful, on account of the small wearing surface. The guide-blocks are made in halves, so that wear can be taken up. It is for the same object that the two cross-heads are made separate.

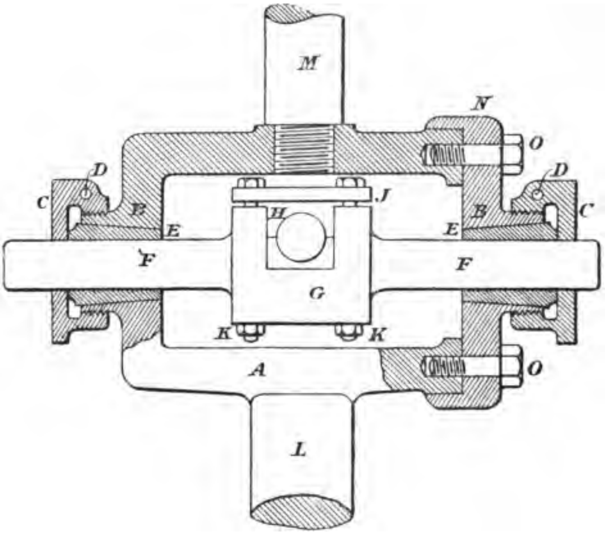
A real slotted link is illustrated in elevation, Fig. 221. It will be seen that the steam piston-rod A, slotted link C, and pump-rod B are all made out of one solid forging; but instead of the plain guide-block J, Fig. 219, it consists of two gun-metal steps, D and E, made adjustable by means of the two wedges F and G, and the two studs secured one to each step. This is of course a more handy way to take up the wear, and acts very well for large pumps; but for small pumps the different parts become very small and soon get out of order, or else the parts must be made extra heavy, and the link becomes excessively bulky.

FIGS. 222, 223.



The yoke, illustrated in Figs. 222 and 223, is very cheap, but is not to be recommended, because there is no provision for taking up the wear. Fig. 222 is a side elevation, and Fig. 223 a plan. It consists of a cylindrical casting, A, furnished with a boss, B, for the steam piston-rod, C, and a boss, D, for the pump-rod E. The two rods are secured in their respective bosses by being screwed or cottered. It will be seen that the casting, A, is cylindrical, bored out, and the slide-block, F, is turned to fit one another, and the block is bored to fit the crank-pin, G. The advantage of this arrangement is evident—namely, that if the centre line of the cylinders and the crank-shaft do not happen to be exactly square one with the other, the turned slide-block will accommodate itself in the bored part of the link or cross-head, but the great disadvantage is, as previously stated, there is no means provided for taking up the effect of wear, so that the block will soon commence knocking.

FIG. 224.



Another yoke is illustrated in elevation, Fig. 224. It is very complicated and rather clumsy looking, but wears well and is to be recommended for large pumps, as it allows for easy adjustment in all the different parts. It consists of the yoke proper, or bow, A, furnished at each end with screwed bosses, B B, provided with split adjusting-caps, C C, the latter having lock-bolts coming through the holes, D D, in each cap, clamping them firmly on the bosses. E E are two taper brass or gun-metal bushes, split in two and turned to fit the taper of the inside of the screwed bosses, B B, and bored to fit the traversing rods, F F. By screwing up the adjusting nuts, C C, these bushes can be made to take up any wear that may occur. The traversing-rods are enlarged in the middle at G, and fitted with a pair of ordinary gun-metal steps, H, cap, J, and two cap-bolts, K K, by which the wear caused at the crank-pin is taken up. L is the pump-plunger, cast in one with the yoke, or the boss may be formed in its place, and a pump-rod screwed in similar to the steam piston-rod M. The end, N, of the yoke is made in a separate piece to allow of the traverse-rods being put into their place; this piece, N, is secured to the other part of the yoke by means of the two screws O O.

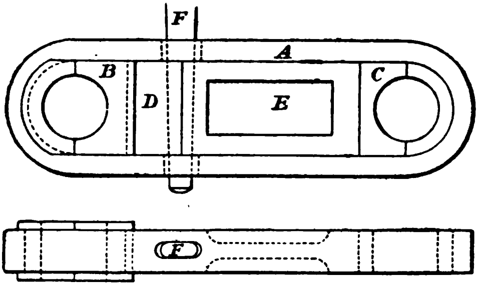
## CONNECTING-RODS.

When the kite or bow is used there must be a connecting-rod to join the cross-head pin (for which provision is made in the kite, as previously described) with the crank-pin or crank-shaft journal. These connecting-rods are of various designs to suit the occasions and the maker's fancy.

A very good, simple, and cheap rod, illustrated in Figs. 225 and 226, consists of a solid welded wrought-iron strap, A; B is a pair of gun-metal steps for the crank-pin or crank-journal, and C a pair for the cross-head pin.

Between these two pair of steps are fitted two cast-iron blocks, D and E, each having one end butting against each of the pair of steps, and being set up by means of a cotter, F, for which the slot, K, in the kite, Figs. 215 and 216, is provided.

Figs. 225, 226.



The connecting-rod, illustrated in Figs. 227 and 228, is of a superior type to the one just described. This rod consists of two straps, A and B, one pair of gun-metal steps, C, for the crank-pin, and another pair, D, for the cross-head pin. Inside the strap, B, and between the two pair of steps, C and D, is provided a cast-iron block, E.

Fig. 227.

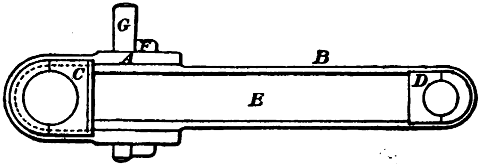
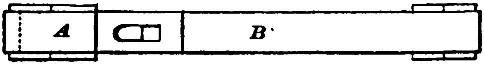


Fig. 228.



F is a gib and G a cotter, by means of which both pair of brasses are set up at the same time. Sometimes the connecting-rod, illustrated in Fig. 206, consisting of two marine ends coupled together by two bolts, is used for this purpose.

## REMARKS ON DESIGNING KITES, YOKES, AND CONNECTING-RODS.

The bolts in the yokes or slotted-links should be turned and the holes in the links rimered out, to make a perfect driving fit, and they should be furnished with nuts and split-pins, or else double nuts.

The bolt-heads are frequently, for the sake of neatness, made cheese-headed.

The collective area of the two bolts should be equal to the area of the piston-rod at the bottom of the thread of the screw, for which see Table II., showing the strength of bolts, both of wrought-iron and steel.

Great care should be taken in having the piston and pump-rods or plunger in a perfectly straight line, also to have the slot in the link at right-angle to the centre line of the two rods.

When the piston and pump-rods are cottered into the slotted-link, some makers have the ends taper, others parallel and cottered up to a shoulder; the latter is the cheapest method, and answers just as well.

The crank-shaft should always be exactly at right-angle to the centre line of the pump and steam cylinders, or else the link will have a wobbling motion, which produces a great deal of wear and looks very bad.

The slide-blocks in the slotted-links should be made with a large bearing surface, by that means reducing the knocking, as they will wear longer, and hence do not require to be set up so often.

The length of the connecting-rod is usually made about one-and-a-half times the length of the stroke of the pump.

The cotters in the connecting-rods should have a taper of one in sixteen; if the taper is more there must be a set-screw provided on the side of the rod, or a split pin through the smallest end of the cotter, to prevent it working out.

Gib and cotter is to be preferred before only the cotter, as the two are parallel, hence the slot in the blocks, D and E, Figs. 225 and 226, and in the strap, A, will be straight instead of taper.

A solid welded strap makes a cheap rod when both the crank-pin and cross-head pin are of the same diameter; but when they are not, the brasses must naturally be made too heavy for the cross-head pin, or the rod must be made with two cotters, as the blocks cannot slide in a taper strap.

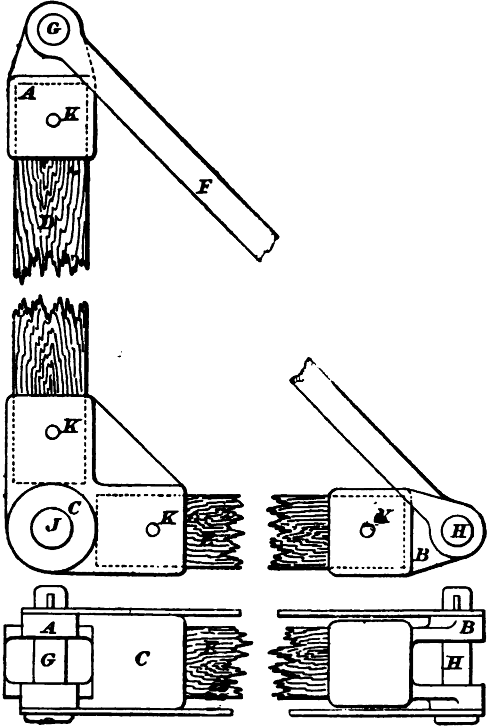
The connecting-rods for hand-pumps when the kite (illustrated in Figs. 217 and 218) is used, consists of an ordinary marine end, for the crank end, into which is screwed a round wrought-iron rod, furnished with a fork for the cross-head end, and secured to the kite by a pin, washer, and split pin.

## L-BOBS, T-BOBS, ANGLE OR V-BOBS, AND BALANCE-BEAMS.

The use of these is to communicate the motion of the horizontal spears to the vertical spears or pump-rods. When L-bobs are used they are usually made in pairs facing one another, and coupled together by a pair of horizontal rods, previously described under the head of "SPEAR-RODS." In this arrangement one set of pumps is coupled complete to each L-bob, so that when one set is drawing the other is delivering. When a T-bob is used, one leg is mostly for the purpose of balance-weights, to balance the working parts in the shaft; the engine then has only to lift the actual water load, when bucket-lifts are used, and the superfluous load, when plunger sets are employed. V- or angle-bobs are used when the shaft or workings are at an angle of less than 90 degrees to the horizontal spears, or in shafts in mines which are not perpendicular all the way down, when they are called "FEND-OFF-BEAMS." The latter name is also used for single arms, as will be explained under the head "ROCK or *rocking-arms.*"

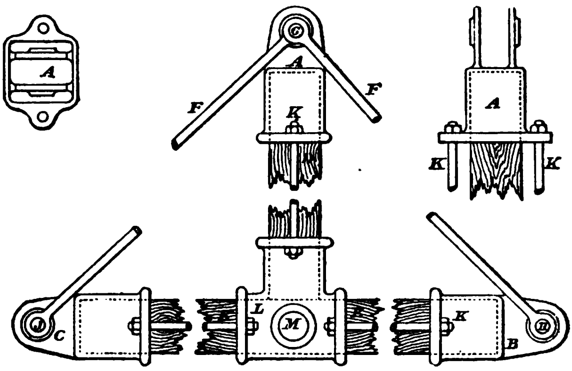
The simplest form of L-bob is illustrated in elevation, Fig. 229, and plan, Fig. 230. It consists of two cast-iron heads, A and B, and a cast-iron centre C. G is the gudgeon for the horizontal spears, and H the gudgeon for the vertical or pump spears. J is the main gudgeon, which is securely keyed into the boss C, the outer ends of the gudgeon being carried in journals, which will be described further on. F F are two tie-rods, secured on to the two gudgeons, G and H. K are bolts, one on each of the heads and two in the cast-iron centre, C, for preventing the timbers coming out of their sockets till the tie-rods are put on, and in case of either or both tie-rods breaking by accident. If it is desired to make a **T**-bob of this type, a third socket must, of course, be cast on the centre, C, and two additional tie-rods must be provided. D and E are two pieces of timber, usually pitch pine, which are carefully fitted into all the sockets.

Figs. 229, 230.



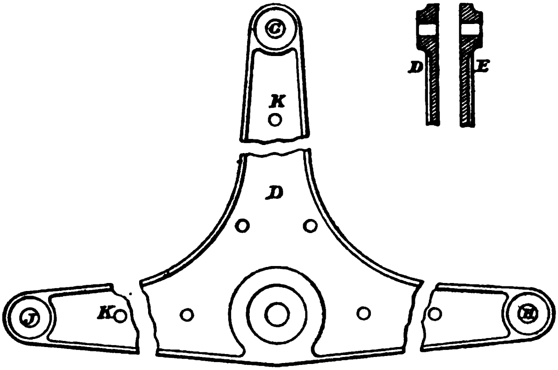
A wood T-bob is illustrated in elevation Fig. 231. Fig. 232 is a plan of the top-head, and Fig. 233 an end view of the same. In these figures A is the top-head, B and C the end-heads, L the cast-iron centre, M is the main gudgeon, G the gudgeon for the horizontal spears, J and H for the vertical or pump spears, if pumps are worked from each end; if not, one of them carries the balance-weights, or is simply a plain stay. E is the horizontal timber, which passes straight through the centre casting, L, and a hole is bored through its centre, through which the main gudgeon, M, passes. F F are two sets of tie-rods, which in this case are round instead of flat, as shown in Figs. 229 and 230. D is the upright beam, generally termed the king's post, and the centre or head, A, is termed the king's head, or bishop's head. The bolts, K, are either made as shown in the illustration, that is, plain rods screwed at each end and provided with nuts, which is the cheapest and simplest, or at other times a head is forged on one end, the other being screwed and provided with a nut.

FIG. 232. FIG. 231. FIG. 233.



Cast-iron T- and L-bobs, or quadrants, have been for years very much used, but are now being displaced by those made of wrought iron and mild steel. One type is illustrated in elevation, Fig. 234, and part sectional end view, Fig. 235. D and E are two cast-iron sides keyed firmly to the centre gudgeon, M, at such a distance apart as to allow for the width of the gun-metal steps in the strapping-plates, which in this example is 6 inches; G is the gudgeon for the horizontal spears, and H and J the gudgeons for the vertical or pump-spears. This example was made for a set of pumps 8 inches diameter by 4 feet length of stroke, raising water from a depth of 300 feet, of 9 inches diameter pump-trees; the centres of the three gudgeons, G, H, and J, from the main gudgeon, M, being 7 feet 6 inches. The main gudgeon was 5 inches diameter, and the other three gudgeons 3 inches diameter. K are bolts furnished with distance-pieces to keep the two sides the proper distance apart; they consist of wrought-iron tubes cut to the proper length, or cast-iron ferrules. Sometimes tie-rods are provided between the centres, as

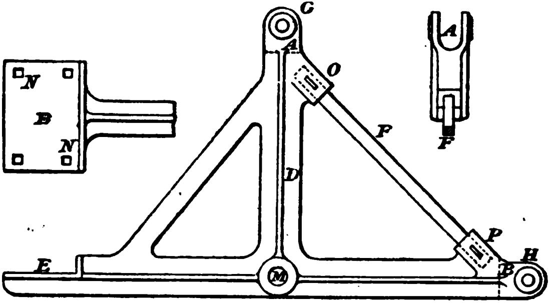
FIG. 234. FIG. 235.



shown in Fig. 229. The two sides, D and E, should be securely bolted together, and the holes bored, when they are in that position, to ensure the holes being exactly opposite one another, and perfectly true and parallel with the gudgeons, so as not to get any twist on them, which twist, if it exists, produces both undue strain and wear.

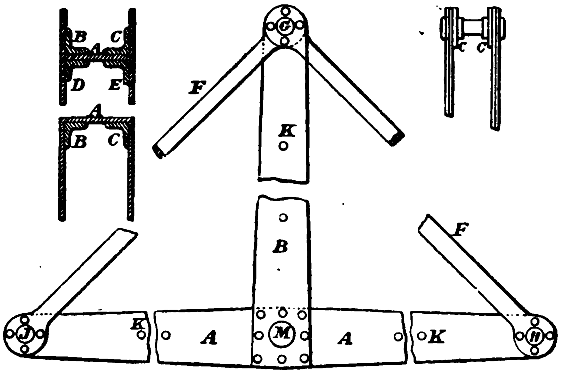
The best arrangement of cast-iron T- and L-bobs, so far as the balance-weight and ease of boring is concerned, is illustrated in elevation, Fig. 236, plan of table for balance-box, Fig. 237, and part end view showing fork end into which the strapping-plates work, Fig. 238. D is the main casting; E, table for balance box; M, main or

FIG. 237. FIG. 236. FIG. 238.



centre gudgeon; G, top gudgeon for the horizontal spears; and H, gudgeon for the vertical or pump-spears. The forks at A and B are made just deep enough to allow a clear working-space for the horizontal and vertical spears. The balance-box or balance-weight, as the case may be, is bolted to the table, E, by means of bolts passing through the four bolt-holes, N, cast in for that purpose. All the centres must be carefully bored to fit the gudgeons, and the bosses faced for the head and nut, or cotter of the gudgeon. The gudgeons, G and H, are keyed into one of the side bosses to prevent them from turning round in the cast-iron. This example is in connection with a 16 inches diameter bucket-lift, 5 feet stroke, raising water from a depth of 300 feet. The centres of the main gudgeon, M, to the centres of gudgeons G and H, is 7 feet; the main gudgeon was 6 inches diameter, and the two gudgeons, G and H, 4¼ inches diameter. Instead of an ordinary tie-rod, as shown in Fig. 229, a rectangular rod, F, is cottered into two bosses, O and P, provided in the main casting, the rod and cotters being placed in the mould and cast in.

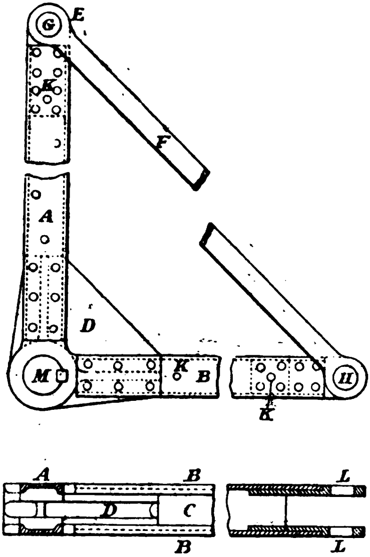
FIGS. 241, 242. FIG. 239. FIG. 240.



For heavy pumping the cast-iron T- and L-bobs are sometimes cast with a box-section, instead of the cross-section illustrated in Fig. 236.

Wrought-iron T- and L-bobs are now mostly used, both on account of lightness and non-liability to break. A design of wrought-iron T-bob for light work is illustrated in Figs. 239 and 240, Fig. 239 being an elevation, and Fig. 240 part end view. A is the horizontal arms, and B the vertical arm, made of best boiler-plates firmly riveted together to form the T. C C are two plates riveted on the inside of each extremity of the arms to make a longer bearing for the gudgeons G, H, and J. Two plates are also riveted on the inside to form a bearing for the centre gudgeon, M. F F are four tie-rods, two between the centres G and H, and two between G and J. These tie-rods are sometimes riveted to the arms, as shown; at other times they take hold of the gudgeons themselves, as shown in Fig. 231. The former plan is to be preferred, as it helps to form a longer bearing for the gudgeon; but it is not always convenient. When the T- or L-bob has to be transported any great distance, in such cases the tie-rods are made independent of one another. In some instances the ends of the tie-rods are forged in one at the top gudgeon; this plan is also inconvenient for transport. K K are stays, consisting of plain bolts passing through wrought-iron or cast-iron ferrules, which always keep the plates the same distance from one another, and prevent buckling. Sometimes, instead of the stay-bolts, a piece of pitch-pine is secured by bolts between the tie-rods, when plunger-pumps are used, and in such cases it is a buckling stress on them. Another method of staying the T- and L-bobs is illustrated in cross-section, Fig. 241, which consists of a plate, A, secured to each of the cheeks by the top and bottom L-irons, B, C, D, and E. At other times the plate, A, at the balance-weight end is put on the top of the side cheeks, and is used for carrying the balance-weight or box, as shown in Fig. 242, when only two L-irons, B and C, are required. The example before us was constructed for a 6 inches bucket-lift, 4 feet length of stroke, for raising water from a depth of 200 feet. The cheeks were 10 inches wide at the centre, tapering down to 6 inches at the gudgeons, G, H, and J, and $\frac{1}{2}$ inch thick; the tie-rods were 3 inches wide by $\frac{1}{2}$ inch thick, the centre gudgeon was 4 inches diameter at the middle, the bearings 3½ inches diameter by 4½ inches long; the gudgeons, G, H, and J, were 2½ inches diameter by 3¾ inches long in the centre, and 2¼ inches in the plates. The stay-bolts, six in number, were ¾ inch in diameter, the ferrules being made of gas-pipe 1 inch diameter internally.

FIGS. 243, 244.



A very good and strong L-bob is illustrated in elevation, Fig. 243, and sectional plan, Fig. 244. It differs from the one last described, inasmuch that the cheeks, A and B, are made of channel-iron instead of wrought-iron plates, while the space between them is filled up with balk of pitch-pine, C, the latter being secured by the bolts, K K. G is the gudgeon for the horizontal spears, H for the vertical or pump spears, and M the main-gudgeon. F F are the two tie-rods, which in this example are of a rectangular section. D is a cast-iron centre-boss to which the channel-irons are fitted and securely bolted, each provided with six bolts. E and L are two pairs of wrought-iron brackets securely riveted to the channel-iron for carrying the gudgeons, G and H.

Frequently L- and T-bobs are made of plates instead of channel-iron, the plates being secured to a cast-iron centre, and the end-bosses riveted to the plates, the plates being stayed by through-bolts and cast-iron ferrules.

The balance-weight end of the T-bob consists sometimes of two cast-iron levers keyed on to the main-gudgeon and connected to the top-gudgeon by two tie-rods.

For very heavy pumping the wrought-iron L- and T-bobs are sometimes made of the box-section, similar to the rocking-arm illustrated in Figs. 256 and 257.

The balance-weights are mostly put into large boxes made of wood, wrought iron, or in a few cases of cast iron. The weights consist of any heavy material or refuse about the mine or colliery, such as stones, scrap-iron, clinkers, &c. These boxes are placed on the top of the balance-arm of the T-bob. Sometimes wood beams are bolted up to it, and the box slung on it or bolted up to it. In a few odd cases the balance-end is straight and passing through the middle of the box. The author has also seen balance-weights consisting of round cast-iron weights slung on a rod secured to the gudgeon, J, but this is a practice not to be recommended, as the weights are kept continually vibrating, which gives a jerky motion and causes a great deal of wear on the gudgeon.

When two L-bobs are worked face to face, each coupled to a bucket-lift, one of them working from a greater depth than the other, the L-bob actuating the deepest lift should have a balance-arm on it loaded to counteract the weight of the extra length of spears, strapping-plates, and bolts, so as to give equal work on each of the L-bobs, or perhaps more correctly, the L- and T-bobs. In one instance, instead of balancing the heavy lift, weights were added to the light-lift L-bob. This is clearly a great error, as it puts weight on to the connecting spears, which connect the two L-bobs, instead of relieving it from the extra weight. A neater and better way would have been to use cast-iron strapping-plates, as illustrated in Figs. 124 and 125, for the light lift, although it causes a buckling stress, but the balance-weight is greatly reduced, because it is placed directly in the line where it is required.

## V- OR ANGLE-BOBS.

V- or angle-bobs are simply L-bobs in which the two arms or legs are of a less angle than 90 degrees. The use of these V-bobs is to suit the different inclinations for passing the main-rod from one inclination to another. The Cornish rule for the length of the arms is 20 inches long for each foot of stroke of the pumps, and the inclination is such that they should be at right angles to the line of motion at half-stroke. They are made in a similar manner to the L-bobs; when of a small size, they are made of solid V-shaped plates. In Cornwall they are built up of wrought-iron forged links, as illustrated in Figs. 245 and 246. A A and B B are four wrought-iron links, keyed on to the centre or main-gudgeon, M, and one pair of links are secured to the gudgeons, G and H;

K are stay-bolts, furnished between the links with wrought-iron or cast-iron ferrules.

In many cases the space is so small that V-bobs or fend-off-bobs cannot be used; then a different method must be adopted. One arrangement is illustrated in Fig. 247, adoptable for bucket-lifts only. It consists of a vertical or angular rod, A, and a horizontal or inclined rod, B, connected by means of an ordinary chain, or sometimes a wire-rope, working over a pulley or runner, D, securely fixed to a beam, E, by a bracket, F, the former being built into the sides of the well or shaft.

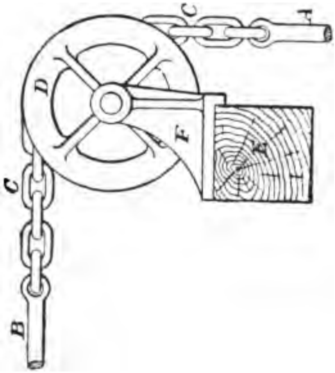


FIG. 247.

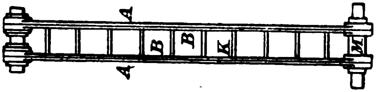


FIG. 246.

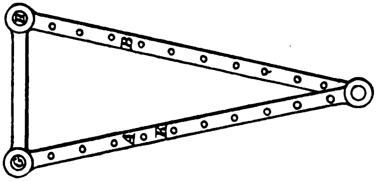
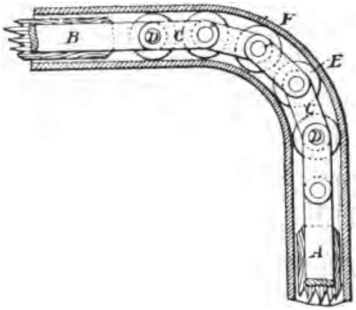


FIG. 245.

Another better contrivance is illustrated in Fig. 248, which is adoptable both for bucket-lifts and plunger-sets. A are strapping-plates secured in the usual manner to vertical or inclined wood-spears or wrought-iron rods, B are strapping-plates secured to horizontal spears or rods, C C are wrought-iron links forming a chain connecting the vertical and horizontal spears; on each of the pins, D D, work small rollers, E E; these rollers run in a rectangular cast-iron pipe, F. The number of rollers, E, and links, C, depends upon the length of the stroke, and the centres of the rollers depend upon the links clearing the inside of the pipe, F. This latter arrangement is an American invention.

Fig. 248.

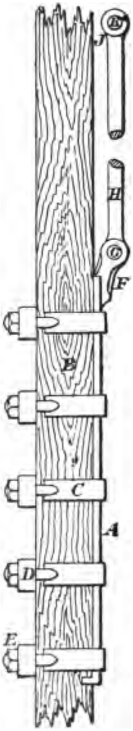


## Balance-Beams.

These beams are placed at intervals down the shaft, in deep mines, to relieve the engine from part or the whole superfluous weight. One is always fixed near the mouth of the shaft, when a beam engine is used or when a T-bob is not employed. These beams are sometimes made of wood, sometimes an ordinary cast-iron beam is used, and again at other times they are made of wrought iron. In most cases they are in appearance simply a T-bob, with the vertical arm or leg made short.

The method of securing these beams to the spears is illustrated in Fig. 249. There is a plate, A, secured to the spears, B, by staples, C, glands, D, and nuts, E; the plate, A, is at the top furnished with a fork or prong, F; to this fork is secured a rod, H, by means of a pin, G; the rod is also furnished with a boss, J, at the top end, which boss is secured to the balance-beam by the pin or gudgeon, K.

FIG. 249.



## REMARKS ON DESIGNING L-BOBS, T-BOBS, V- OR ANGLE-BOBS AND BALANCE-BEAMS.

The distance from the centre gudgeon M to the gudgeons G, H and J, Fig. 239, is varied very much by different engineers, and depends greatly upon bringing in old patterns and drawings, but a good rule is to make the centres one-and-a-half times the length of the stroke. The Cornish practice is to allow 20 inches for each foot of length of stroke of the pumps.

The horizontal leg of a T-bob, which carries the balance-weight, is sometimes made longer than the other two legs, so as to bring the centre of gravity of the balance weight further from the centre gudgeon, so as to reduce the size of the balance-box, or the bulk of the weights. This can of course not always be done, because if the centres are short and the stroke long, as is frequently the case for the sake of cheapness and tightness, the balance-box or weight will come sooner in contact with the horizontal spears; still, however, the box can be reduced in height to compensate for the shallow space. Of course, when the weight is hung from the back or balance-weight gudgeon, which is sometimes done, as has been already mentioned, it matters not, as it will be clear of the spears; in such cases the suspension-rod should be stayed to prevent the weight from swinging backwards and forwards at each stroke, or if a weighted box is used, it may be bolted up to the underside of the leg of the T-bob, and the plate, A, and L-irons, B and C, Fig. 242, placed on the bottom—instead of the top side of the balance leg.

The gudgeons, G, H and J, are made in different ways; some make them with a solid head at one end and a washer and cotter at the other; some dispense with the washer and employ only the cotter; other engineers have a plain straight pin and a cotter at each end; again, we sometimes find them made like an ordinary turned bolt with head on one side and nut at the other; this is specially the case for small light work. In several instances the writer has seen them reduced in diameter through the cheeks and riveted over on the outside; this latter plan is decidedly bad, as it entails a great deal of labour when they have to be renewed.

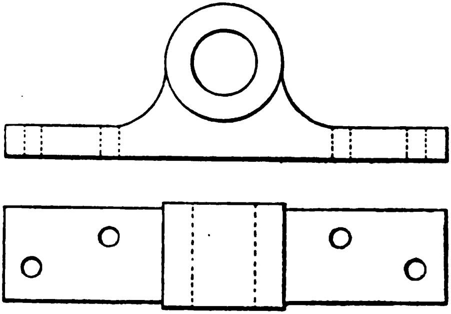
All rivet-holes should be drilled and be perfectly fair one with the other.

All bolt-holes should be drilled and the bolts turned to a good driving fit, and a split-pin provided outside each nut, as there is a constant vibration on the bolts.

The tie-rods are sometimes made rectangular, as shown in Fig. 229, or at other times round, as shown in Fig. 231.

The sectional area of the pair of tie-rods does not require to be larger than the area of the bucket-rods at the top; the width is usually, when rectangular rods are used, made the same as the diameter of the gudgeon for the strapping-plates, and the thickness the same as the plates in wrought-iron L- and T-bobs. For plunger-pumps a margin for buckling must of course be allowed, which margin, if calculated, will involve very intricate formulas, hence it is usually got from experience, but the best plan is to make them strong, and put in plenty of stays or securing timbers between the two tie-rods. The stress usually allowed for tension of wrought iron is 2 tons per square inch; and 3 tons for steel.

FIGS. 250, 251.

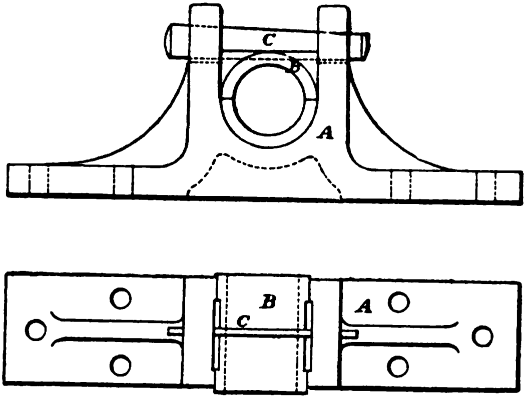


The timbers for wood-bobs must be carefully fitted into the cast-iron heads and centres.

The bearings for the L- and T-bob gudgeons are for small work made solid, as illustrated in elevation, Fig. 250, and plan, Fig. 251; and even for large bobs, some engineers, although it is not advisable, for the sake of cheapness; the example before us was made for a 5½-inch diameter gudgeon.

A good bearing is illustrated in Figs. 252 and 253, the former being an elevation and the latter a plan. In this case the bottom half of the steps were cast in one with the body A; B is the top step secured by means of the cotter C, to prevent the gudgeon from jumping out in case of an accident; the cotter is forged to fit in the cotter hole, which latter is cast in. The gudgeon in this case was 6½ inches diameter, and the steps 10¼ inches long; the sole-plate was 4 feet long by 10 inches wide, secured by six bolts, 1¼ inch diameter.

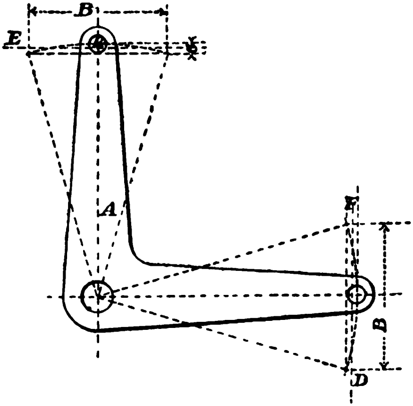
Figs. 252, 253.



In very good work ordinary pedestals are used fitted with gun-metal bottom steps, the top half usually being fitted with loose cast-iron steps. Some engineers cast the top step in one with the cap.

In fixing the L- and T-bobs the centre line of the pumps and horizontal spears must coincide with half the *versed sine* of the arc described by the centre of the gudgeons in the horizontal and vertical arms. To explain this more clearly we must refer to the illustration, Fig. 254, which is an ordinary L-bob. A is the L-bob, the distances B and C are respectively the strokes of the horizontal and vertical spears. Now describe an arc from the main gudgeon, H, with a radius H J, passing through the gudgeon, J, for the vertical spears; next draw a line through the centres of the gudgeon J in the top and bottom positions, and the line, D, the centre line of the pumps, will be half of the distance F, which is measured from the perpendicular line to the centre of the gudgeon, J, in mid-position. The same process must be carried out at the gudgeon K, which makes the line E the centre of the horizontal spears.

FIG. 254.



## ROCK-ARMS AND FEND-OFF BEAMS.

Rock-arms and fend-off beams are used for supporting long horizontal spears, or for fending off the rods in mine shafts that are not perpendicular the whole of the way, and used instead of V-bobs, as there is less excavation required with the fend-off beams than with the V-bobs, which is a great consideration in many cases. These arms or beams are made of wood and cast-iron heads; altogether of cast iron; or altogether of wrought iron.

Wood and cast-iron rock arms are usually made like the vertical arm, D, Fig. 231, with the sockets for the horizontal arms, E, in the centre boss removed.

Cast-iron rock arms are like the vertical arm of the T-bob, illustrated in Fig. 236. The top and bottom gudgeons G and M are mostly made the same diameter.

Wrought-iron rock arms for light work are made as illustrated in Figs. 255 and 256. Fig. 255 is an elevation, and Fig. 256 an end view. A and B are two wrought-iron boiler plates, furnished on the outside, top and bottom, also on the inside at the bottom, with round washer plates, C, D, E, F, N and O, securely riveted to the cheeks A and B. K are two bolts fitted with wrought-iron tube ferrules, L. G is the top gudgeon for the strapping-plates to take hold of; this gudgeon being furnished with fixed collars and riveted into the two side plates A and B. M is the bottom gudgeon on which the rock-arm vibrates. This gudgeon is larger in diameter between the plates to keep them the proper distance apart.

A wrought-iron rock-arm for heavy lifts is illustrated in end view, Fig. 257, and cross-section, Fig. 258. Instead of the distance-pieces, K, in the last example, it is made of the box section, as shown in plan. A and B are the two side plates, C, D, E and F are four round washer plates, as before, but in this case they are riveted to the inside of the plates A and B; J and K are two end plates, which are securely fastened to the plates A and B by means of the four L-irons N, O, P and Q; G is the top gudgeon, and M the bottom gudgeon, arranged, as in the previous example.

FIG. 255.

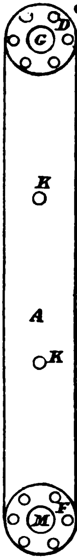
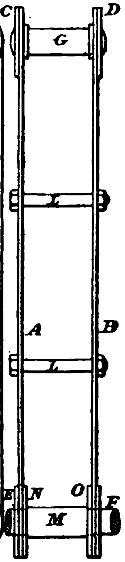
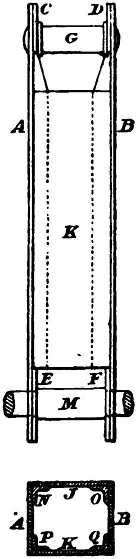


FIG. 256.



FIGS. 257, 258.



## REMARKS ON DESIGNING ROCK-ARMS AND FEND-OFF BEAMS.

The remarks on designing rock-arms and fend-off beams are exactly the same as for L- and T-bobs and angle-bobs and balance beams.

## CISTERNS OR TANKS.

Cisterns or tanks are placed at the top of each lift in the shaft or well, and the bucket-lift or plunger-set resting on the bottom of each cistern, the cistern itself resting usually on timbers, sometimes on cast-iron, or wrought-iron girders, but timber is the best. When a bucket-lift is placed at the bottom, this delivers the water into a cistern in which a plunger-set is fixed; this again to a cistern higher up, for the next plunger-set to draw its water from, and so on to the top of the shaft. These supports must be made strong enough to sustain the weight of the whole lift and the water contained in it, and if plunger-sets are employed, it must also withstand the whole of the downward pressure produced by the plunger. The wood beams, or as they are called in Cornwall, "wood bearers," are fitted securely into the sides of the shaft; they are 8 inches to 10 inches square, ofttimes six to eight in number, one placed on the top of the other. In many instances one side of the cistern is fixed in the side of the shaft and the other resting on bearers.

The cisterns are mostly made of wood, at other times of wrought iron, but very seldom of cast iron. The minimum size of cistern is three times the capacity of the pump drawing the water from it, but the larger it can be got in the shaft the better, as the continued delivery of water into it and the drawing from it causes agitation of the water, and a deal of air mixes with it, consequently the pump will be drawing air when it should draw water; hence, the deeper the cistern is made the better. Their usual size for large pumps is 4 feet to 5 feet wide, 6 feet long, and 4 feet to 5 feet deep.

The wood cisterns are made of yellow-pine, Norway balk, and sometimes, though very seldom, of oak. The bottom is made 6 inches thick, and the sides and ends about 3 inches thick. They are made in various ways; the best is to groove the sides and bottom, slide the ends down, and secure the whole together by long bolts. Another method consists in having upright pieces of timber, forming the corners and the sides and ends bolted to the uprights.

The wrought-iron cisterns are made from boiler plates $\frac{1}{4}$ to $\frac{3}{8}$ inch thick, with $2\frac{1}{2}$ inches to 3 inches L-irons, $\frac{3}{8}$ inch thick round the top, bottom, and at the corners, the shape of it being made to fit the sides of the shaft.

Cast-iron cisterns are not much used on account of the great weight necessary to withstand the heavy roads resting on them, and the shocks they are subjected to. They are made in the usual manner, the joints being bolted together and caulked with rust cement.

Collar launder is the usual name given to the spout fitted to the top of the pump-trees, the object of which is to guide the water into the cistern. They are usually made of wood or wrought iron, the former being mostly adopted. They are frequently very long and of a peculiar shape to suit the circumstances, so as to carry off as much of the air contained in the water as possible, and the outlet end lowered down by a gentle slope into the water in the cistern. Too much care cannot be taken in this matter, so as to cause the minimum amount of motion of the water. Where the shaft and pumps are small, the pump-trees are made to enter or deliver the water at the bottom of the cistern; this has also the advantage that it reduces the amount of set-off in the rods; the disadvantage is that it sets the water in the tank in motion, causing the air to mingle with the water; also that when the pump-trees have to be repaired the tank must be emptied before anything can be done to them.

## MINOR DETAILS.

### CLACK-PIECE DOOR-CHAINS AND CRANES.

When the clack-piece doors are of a large size and heavy, provision must be made for removing them and holding them in position till such times as they have to be replaced and bolted up again. One arrangement used for very heavy doors is illustrated in Figs. 259 and 260. It consists of a wood or wrought-iron beam, A, secured in

FIG. 259.

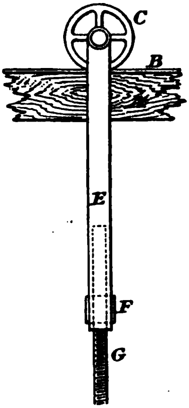
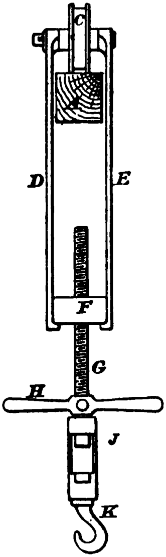


FIG. 260.



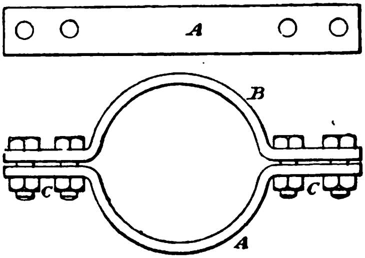
the sides of the shaft; on the top of this wood-beam, if of wood, is screwed a wrought-iron plate, B. On this plate rolls a runner, C, to the spindle of which is secured two side-links, D and E, which latter are furnished at the bottom with a cross-piece, F, screwed in the centre to receive the screw, G. The bottom of the screw is provided with a cross-piece, H, for turning it round; below that again is a swivel, J, furnished with a hook, K. The hook, K, is fastened to the eye provided on the door, or a sling chain secured to it, the cross-piece, H, turned round till the hook has got the weight of the door, then the whole is pushed out of the way along the beam.

Small doors are removed by means of a chain secured to some part of the pump work, the chain being provided with a swivel screw, and the whole swung out of the way.

### YOKE OR CLIP

A yoke or clip is illustrated in elevation, Fig. 261, and plan, Fig. 262. It consists simply of two pieces of

FIGS. 261, 262.



wrought iron, A and B, of such shape that the two bolted together by the bolts, C, form a round clip, a small space being left between them so as to grip better. They are secured round the pump underneath the strengthening belts or the flanges, the ends being made long on purpose for them to rest on bearers, secured at intervals down the shaft to relieve the cistern of part of the weight. The size and strength of the iron depends, of course, upon the size and weight of the pump, pump-"trees," &c. The length of them is usually 10 to 12 inches past the outside edges of the flanges, so as to rest on timbers 8 to 10 inches wide.

## FISHES AND DRAW-HOOKS.

When the clack-piece doors of bucket-lifts are covered with water, so that access cannot be had to the clack, the clack and seat must be drawn up through the pump-"trees;" for that purpose the fish or draw-hook is used. One of these fishes is illustrated in Figs. 265 and 266. It consists of a rod or shank, A, and half of a knock-off joint, B, which is made interchangeable with the knock-off joints on the bucket fork or sword, as the case may be. The bottom part, C, is made in the shape of a fork. In this fork are fitted two catches, D and E, held out by a spring, F. The catches are secured by the pins, G and H, and the spring by the pin, J. The bottom part of the fork is provided with a distance-piece, K, secured to the fork by means of the three rivets; the

FIG. 263.

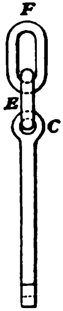
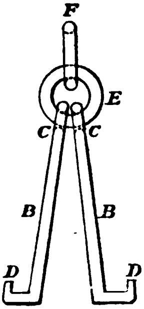


FIG. 264.



distance-piece forms also a stop to prevent the catches springing out too far.

Another type of fish, a slight modification of the

FIG. 265.

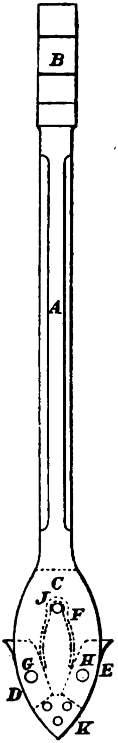


FIG. 266.

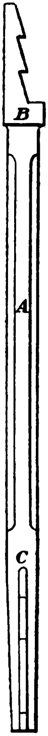


FIG. 267.

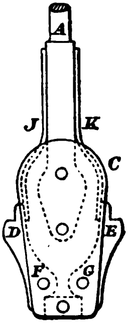


FIG. 268.

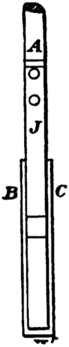


FIG. 269.

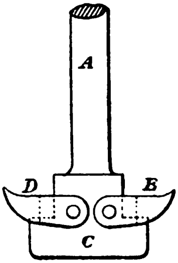
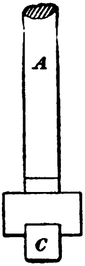


FIG. 270.



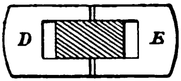
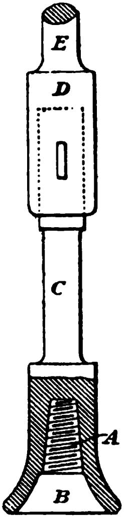


FIG. 271.

previous one, is illustrated in Figs. 267 and 268. A is the shank, which can be fitted either with a knock-off joint or a Y-piece. Instead of the bottom end, C, being made in the shape of a fork, it is provided with two holes, by which two plates, B and C, one on each side, are riveted to the shank. The two catches, D and E, are pivoted in the plates by the pins, F and G. At the bottom is provided a distance-piece, H, to prevent the catches from opening too far. J and K are two springs, secured to the shank, A, to keep the catches up to their work. This fish was made for a working barrel 4½ inches diameter, the shank ⅝ inch diameter, the plates being ¼ inch thick, and the pins for the catches ⅜ inch diameter.

A catch for drawing pumps and pipes is shown in Figs. 269, 270, and 271. A is the shank, which can be provided with a knock-off joint or Y-piece, which latter is securely bolted to spears, sometimes the ordinary spear-rods. At other places a set of spears are kept for that purpose only. Again, at other times only a bottom length is kept specially for that purpose. The bottom part, C, is made in the shape of a T. D and E are the two catches pivoted on pins, secured to the T-part, C.

FIG. 272.



The ordinary fishes cannot be used in drawing all the different classes of valves. When the valve is arranged with a spindle, as illustrated in Fig. 94, the method adopted for drawing the valve is shown in Fig. 272. The spindle of the valve is turned and screwed taper, and the fish is bored out and screwed to fit the spindle at A, and a bell-shaped end, B, is projecting below the screwed part, so as to guide it into the spindle; the shank on the fish is either cottered into a socket on the end of the pump-rods, as illustrated in the example before us, or is secured to the ordinary spears by the usual knock-off joint, as illustrated in Figs. 265 and 266.

The links for lowering the clacks and seats after they have been repaired or releathered, are illustrated in Figs. 263 and 264. They consist of two forgings, A and B, provided with an eye, C, at the top and a hook or heel at the bottom end at D. These two forgings are joined to a round ring E, secured to an ordinary chain by a long link F.

Sometimes the clacks are lowered simply by a hook, consisting of a round rod provided at the top with the bottom half of a knock-off joint and at the bottom with a plain hook. This arrangement is used when the clack is fitted with a ring or eye, as shown in Fig. 90.

## Raising and Lowering Pumps and Pipes.

Pumps, when used for sinking, are frequently slung in the shaft by means of chains or wire ropes, provided with adjusting screws, and lowered down as the sinking progresses, and raised and lowered by means of a windlass or capstan.

The usually adopted method of arranging the pump in a shaft is to commence with a bucket-lift, and sink until a point has been reached where the first plunger-set will be permanently secured. When this pump and pump-trees are fixed sinking is again proceeded with the bucket-lift, and so on till the desired depth has been reached. In some places abroad they commence sinking with the plunger-set; when the intended position is arrived at the bucket-lift is introduced if the shaft is shallow; if not, as many plunger-sets are lowered as required, finishing with a bucket-lift at the bottom.

The use of lifting-screws, in connection with bucket-lifts, is to lower them as the sinking proceeds, when additional pump-trees have to be added. They are used also for lowering or raising any details of the pumps, when they are broken or in any other way damaged. The screws are from 2 to 4 inches in diameter and 5 to 12 feet in length. The screwed parts work in large nuts working on bearers secured to the sides of the shaft, and turned round by large spanners varying from 3 to 5 feet in length. The bottom end, of these screws, is formed into an eye, by which they are secured to the pumps. In some instances the eye at the bottom is secured to a swivel and the screw turned round, instead of the nut, the screw at the top being provided with a square for the spanner to take hold of, or holes are bored to receive a round bar. When the sinking has proceeded so far that the pump is no longer able to fetch the water, the pump is lowered sufficiently to introduce another length or two of pipes under the pump-trees already fixed. When these pipes have been added, the spears must be lengthened, all coupled up, and the sinking recommenced.

FIG. 273.

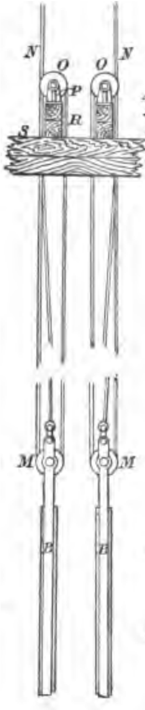
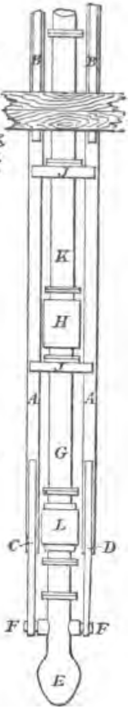


FIG. 274.



Two good methods of raising and lowering the bucket-lifts are illustrated in Figs. 273 and 274, and Figs. 275, 276, 277 and 278.

FIG. 275.

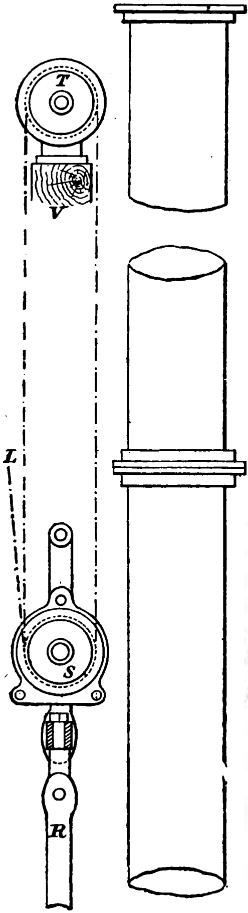
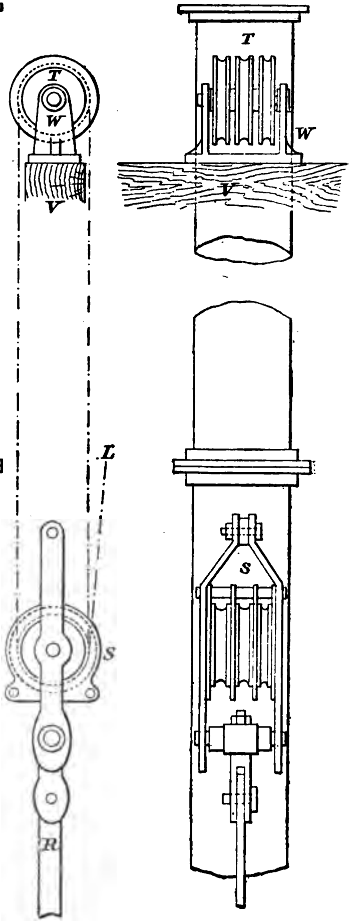


FIG. 276.



The first arrangement is illustrated in elevation, Fig. 273 being the top part, and Fig. 274 the bottom part of the raising and lowering tackle. E is the windbore, of the heartshaped type furnished with two strong lugs or trunnions, F F, cast in one with it; G is the working-barrel; L the clack-piece; H the bucket-door-piece; J J are two cross-pieces of wood, secured, the top one, under one of the flanges of the pump-trees, K, the other under the bottom flange of the bucket-door-piece, H, for guiding and steadying the whole of the bucket-lift; A A are two wood spears, secured to the trunnions, F F, on the windbore, by means of the strapping-plates, C D. The top of the two spears, A A, are provided with strapping-plates, B B, to which are fitted sheaves, M M, and the whole bucket-lift

FIG. 277.

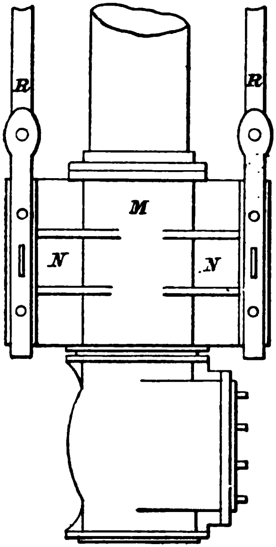
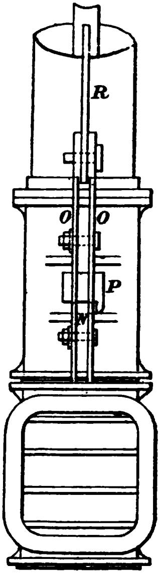


FIG. 278.



is raised and lowered by the ropes, N N, operated by a capstan at the top of the shaft. R are wood beams secured across the shaft on to which are fixed brackets, P, carrying the top pulleys, O O. This arrangement cannot, of course, be adopted when a sliding-windbore is employed.

The second arrangement for lowering the bucket-lift is illustrated in Figs. 275, 276, 277 and 278. Fig. 275 is an elevation of the top tackle; Fig. 276 an end view of the same: Fig. 277 is an elevation of the bottom tackle, and Fig. 278 an end view. Instead of the trunnions, F F, in Fig. 274, there is in this case a short piece of pipe, M, of the same internal diameter as the pump-trees, introduced between the bucket-door-piece and the pump-trees F. This pipe, M, is furnished with two strong lugs, N N, one on each side; to each of these lugs or brackets is fitted a wrought-iron strap, O, secured by means of two strong bolts and a cotter, P. In this example two tie-rods, R R. are used instead of the wood-spears, Fig. 274; these tie-rods are secured at their bottom end to the straps, O O, and at the top fitted with pulley blocks, S S. The ropes, L L, pass round the pulleys, S, at the bottom, and the pulleys, T T, at the top, thence to a capstan or windlass at the top of the shaft, by which they are operated. The pulleys, T T, are running in brackets bolted to the two wood beams, V V, which are built into the sides of the shaft.

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